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THE INSTITUTE OF PETROLEUM

AN Ordinary General Meeting of the Institute of Petroleum was held at 26 Portland Place, London, W.1, on 6 February 1957, the Chair being taken by E. Le Q. Herbert, a vice-president of the Institute.

The Editor read the minutes of the previous meeting, which were confirmed and signed as a correct record. He also announced the names of members elected since the previous meeting.

The Chairman, introducing the author of the paper to be presented, said: To-night we are to hear and to discuss a paper on patents in the petroleum industry and the part which they have played in the development of our industry. The author of the paper is Dr J. T. Tyson, a Fellow of the Institute, and the present manager of the Patents and Contracts Department of Esso Research Ltd. Dr Tyson had considerable experience in the patent world before joining Esso Research some ten years ago, and I feel sure that we are to hear a paper of considerable interest.

Dr Tyson then presented the following paper in summary.

PATENTS IN THE PETROLEUM INDUSTRY*

By J. T. TYSON† (Fellow)

SUMMARY

The purpose of this paper is to discuss the part played by the patent system in the oil industry. The average level of knowledge of patents as a whole among the general public seems to be surprisingly low, and consequently it is advantageous to discuss the subject in three separate parts.

First, there is a general outline of the patent system, followed by a more specific discussion on the role of patents in the oil industry. Following logically from the general pattern of patent distribution in the oil industry comes the subject of patent licensing, and this forms the third part of the present paper.

DEVELOPMENT OF THE PATENT SYSTEM

THE ordinary man's concept of a patent is some rather nebulous possession which entitles its owner to do something or make something which he has invented. This he can do by virtue of the monopoly right conferred upon him by his patent. In many quarters, to define a thing as a monopoly automatically stamps it as a bad thing, and the holders of such opinions probably never trouble to look any further into the basic rights and wrongs of the patent system. For this reason they perhaps do not even know that the patent monopoly confers solely the right to prevent others from using the patented invention, and does not necessarily bestow upon the patentee the right to use his own invention himself. Thus, for example, if one man patents broadly a basically new synthetic lubricant and a second inventor later patents a particularly attractive way of making it, the original patentee cannot use the new process without infringement of the second patent, and the second patentee cannot use his process at all without infringement of the basic patent. The distinction between this and the popularly-held view of a patent right is a matter of considerable importance, as is seen later.

Monopolies in one form or another have existed for some thousands of years. For example, salt was a State monopoly in ancient Rome. It is, however, only within the last five hundred years or so that the State or governing power in a community has bestowed monopoly rights as a favour on one or more of its subjects.

These originally took the form of grants to citizens, in return for some form of public service, of rights to control the manufacture or sale of various commodities. As an example, the private monopoly on salt in the reign of Elizabeth I had the effect of raising its price to the consumer from 6*d* to 14*s* a bushel.

This situation generally caused considerable hardship to the common people and apparently unjustifiable enrichment of the monopolists. In due course public feeling in England reached such a level that in 1623, during the reign of James I, there was passed the Statute of Monopolies, which forms in its essence the foundation of all the patent systems in civilized countries of the world. This stated, in effect, that no monopoly could validly be granted to a subject, with the exception of those given for a limited period of years for what it defined as "a manner of new manufacture." A patent as we know it today is well defined in the booklet entitled "The Profession of Patent Agency" issued by the Chartered Institute of Patent Agents. It says: "A patent for invention is a temporary, qualified, and conditional monopoly granted by the Crown to encourage invention for the benefit of the public at large. It is granted for a limited time, for 16 years in the U.K., and for periods of a similar extent in other countries." The grant can still be made only for a "manner of new manufacture," which is a phrase of some importance and significance. It means that the invention must be

* MS received 16 October 1956.

† Patents and Contracts Department, Esso Research Ltd.

both new and a manner of manufacture. Its effect may be illustrated by a wartime patent application for the use of zinc chloride solutions to extinguish incendiary bombs. Zinc chloride solution was held to be a manner of manufacture, but not new, while its use for this purpose was new, but not a manner of manufacture. The application was accordingly refused.

In effect, the patent constitutes a bargain or contract between the State and the inventor. The inventor provides some new and useful industrial technique or development. In return, the State gives him the right for this limited period of years to take the full benefit of the contribution which he has made to the common weal. As already stated, this contribution must be new, that is to say not previously published or operated, and must also be inventive or, expressing the same thought in patent agents' language, must have " subject matter."

Basically, the procedure for obtaining a patent is the same in all countries. However, the technique used by Patent Offices of different nations varies quite widely. Formal application for a patent is filed together with a Specification, which is a document describing the invention in the fullest practicable detail. Generally speaking, this Specification finishes up with a " statement of claim," which serves the purpose of defining as accurately as possible the monopoly which the inventor wishes to have.

The simplest form of patent procedure is exemplified by the practice in France, where the Patent Application and Specification are merely registered without any form of technical examination as to the merits, novelty, or otherwise of the invention. Should litigation or other trouble ensue, all these matters, together with the question of infringement, are brought up to be thrashed out in the courts.

The U.K. provides an intermediate stage in which the patent specification is studied by a technically qualified examiner who searches the literature for anticipations of the invention, that is to say, partial or complete disclosure in earlier publications. Apart from the general question of whether the invention is a " manner of manufacture " within the meaning of the Act, the British examiner is concerned primarily with the question of whether the invention is new. He does not concern himself with questions of subject matter, or whether the invention really contains some spark of inventive merit. This issue may, however, now be raised by an opponent against the grant of the patent after it has been allowed and published by the Patent Office.

Holland is a good example of the highest level of Patent Office examination, and generally speaking, the grant of a Dutch patent may be regarded as *prima facie* evidence that the invention concerned is a sound one. The examiners are well skilled in their subjects, they perform an extremely thorough search, and they can and do raise the question of inventive subject matter, sometimes to an extent which the patent agent attempting to prosecute the case finds rather disheartening.

The practices of most other countries fall somewhere within these extremes. In passing it might be noted that so-called " world patents," to which one sometimes sees reference, do not exist. It is necessary for the inventor with sufficient faith in his invention to file separate patent applications in each and every country where he feels it would be justified, and the cost of doing this may be quite substantial.

It should also be recognized that the variations of examination technique are a function of the local patent law as applied to Patent Office practice and are in no way a reflection on the skill or diligence of the examiners concerned. The examiner is provided with a set of rules within which he must conduct his examination, and he will be exceeding his duty if he goes beyond its limits.

The most important part of any patent specification is the statement of claim, for it is this that defines the monopoly which the patentee can enforce. For example, if the claim reads " Paraffin wax containing a minor proportion of a tri-alkyl phenol having from 1 to 12 carbon atoms in each alkyl group," that is specifically what the patentee can stop others from making. He cannot prevent the use of other substituted phenols, such as amino-phenols in wax, nor can he prevent the use of tri-alkyl phenols in other petroleum products, such as gasoline or lubricating oils. In framing his claim properly, he generally tends to find himself on the horns of a dilemma. If the statement is too narrow, then others will be able to take advantage of his invention and apply it in their own way without infringing his claim and, therefore, without being liable to him. If, on the other hand, he casts his net too wide and claims his invention unduly broadly, he runs the risk that his patent may be held invalid. In his specification he has described certain advantages which will flow from the use of his invention. If operations carried out under the scope of his claim can in some cases fail to show those advantages, then there is a real danger that his whole patent may be held invalid. This difficulty is particularly strong in the case of chemical patents, where a few members of a chemical class have been shown to operate as intended in the inventive process. The inventor has neither the time, the money, nor probably the inclination to try out all members of the class. If he takes the gamble, claims the whole class, and some do not work, his claim is invalidly broad. If he is cautious and claims only his proven sub-class, a competitor may freely use another sub-class without infringement, and in fact may even obtain patent protection for this sub-class. This point is of some considerable significance to the oil industry, since apart from patents relating to refinery equipment, the majority of patents

in this field are in the chemical class, using the word "chemical" in a sense sufficiently broad to include conventional refining operations such as cracking, reforming, desulphurization, etc.

This problem is sympathetically recognized, however, by the legislature, and the patentee may apply to amend his patent at any time by way of limitation in order to validate it. Similarly, the courts have the right to grant relief in an infringement action on valid claims in an otherwise invalid specification, provided that the invalid specification was framed in all good faith and with reasonable skill.

The above provides an extremely brief and elementary summary of the main principles of the patent system. The next point is to consider what is the advantage of the system.

Probably the greatest single advantage is that it provides a direct inducement to industry to invest money in research and development, and to make known to the public the results of that work, in the secure knowledge that those results will not be stolen. In other words, the patent system provides industry with a form of insurance on its research investments. If research money produces worthwhile results, patent protection on those results should provide the investor with an opportunity to recover his investment with at least a reasonable return. If one tries to visualize an alternative system in which no such protection were available, with the result that all major organizations jealously guarded their own developments as trade secrets, the level of scientific knowledge would be considerably reduced and the present rate of technological and industrial development would be enormously slowed down.

It is probably appropriate at this stage to mention the hoary problem of "abuse of monopoly." Like the poor, we always have with us a vociferous minority who complain that in spite of the benefits just outlined for the patent system, large organizations deliberately mishandle it to their advantage, and to the disadvantage of smaller organizations. For all practical purposes this is impossible. The Patents Act contains provisions expressly designed to guard against such an occurrence, and these provisions have been invoked very rarely indeed. The Swan Commission, on whose Report the 1949 Patents Act was based, was charged specifically to investigate the question of abuse of monopoly and stated that it had found no trace of it. In any case, it is at least improbable that a large organization would find it desirable to deliberately suppress developments of real merit by which better or cheaper products could be made available to the public.

Before passing on to a more detailed consideration of the oil industry, there is one other general field in which the patent system has an important contribution to make, and that is the provision of technical information. Manifestly, patent specifications cannot replace technical journals, magazines, and text-books. They do, however, provide a supplementary wealth of detailed technical information of a type which is not likely to be found in these other sources. The patent literature has a useful role to play in indicating the trend of competitors' activities, and in general one can say that the undertaking of a major research programme without a thorough preliminary investigation of the patent situation in any country where the results of the programme are likely to be applied would be unwise.

ROLE OF PATENTS IN THE OIL INDUSTRY

The patent system as we know it today has developed over a period of some three centuries. The corresponding period for the oil industry is about a hundred years. In both cases, however, the last fifty years have seen the most rapid growth.

The present section of this paper sets out to study the role which the patent system has played in the oil industry and to identify any special characteristics of the industry which have influenced the way in which a major oil company builds up its patent structure.

Fundamentally, the role of an oil company has remained unchanged throughout the period. The industry is concerned with prospecting for oil and its production, transportation, and refining, followed by the distribution of the resultant petroleum products. In the early days the range of products sold was small, kerosine being the principal outlet, and product quality requirements were low. Even now the number of primary products is relatively small, and automotive fuels, such as gasoline and auto-diesel; fuels sold as convenient carriers of B.t.u., such as kerosine, heating oil, and residual fuel, together with a few grades of lubricating oil, form the major part of the petroleum products sold throughout the world.

Product quality requirements, however, have shown a marked increase in severity. Rapid technical progress in the development of the end-use equipment has meant corresponding development of the fuel or lubricant concerned. Present day high-compression, high-speed gasoline engines demand the 98–100 octane gasoline currently sold. Auto-diesel developments demand lubricating oils of ever-increasing detergency. Fresh developments, such as the aviation gas turbine, set the industry an entirely new problem in lubrication. The growth and progress of industrialization create the need for new and better lubricants for machine tools and other industrial purposes.

These problems can be solved only by extensive research and development. This work, by its very nature, is inherently expensive. A standard engine test may cost of the order of £1/hr to run and will last several hundred hours. A fleet test on a new fuel or lubricant may well cost tens of thousands of pounds.

A new refining process will generally be tested out on a large and expensive pilot plant. Altogether, the cost of research and development is such that good protection of the results through the patent system is essential.

In the specialized fields of prospecting and production, patentable inventions normally represent the applications of techniques brought in from outside the industry proper. Examples in the production field are the use of electronics in seismographic surveys and of such procedures as ultra-violet fluorescence and the determination of the C_{12}–C_{13} isotope ratio in the examination of drill cores. So far as production is concerned, most inventions tend to be of a mechanical nature, such as improved drill bits, methods of stacking, drilling pipe, etc., together with a certain amount of development of improved drilling muds.

A line of research more specific to the oil industry is that of process development. Here we have a large number of companies working on an essentially similar raw material to produce an essentially similar and small range of bulk products. The standards of product quality required for these products are also reasonably well established in a given marketing area. Consequently, there is a natural tendency for work of this type to develop on parallel lines within several organizations, which may lead to severe overlapping of the patent structures.

Even with quite new processes on which basic patents may be obtained, different inventors may file patent applications within a few weeks of each other. An example of this is sulphuric acid alkylation for aviation gasoline, in which quite basic patents were filed by at least three major oil companies within a few months of each other in 1938, all based on independent research work.

A more normal course of events is for a basic development to be followed over a period of years by a sequence of improvement patents taken out both by the original inventor and by his competitors. For example, the basic patents of fluid catalytic cracking were filed in the U.S.A. in 1939 and 1940. Even now, patents are issuing on various modifications and improvements in this basic technique. This serves to illustrate quite an important factor in the patentable aspects of oil refining processes. There is little margin in refining economics, and apparently small improvements in yield or product quality may mean tens of thousands of pounds per year to a given operator. Thus a number of process improvements or developments which have a very real economic and commercial value may appear to the uninitiated as trivial. Similarly, it may be difficult from hindsight to recognize the new step as inventive, although it is a modification which undoubtedly represents a real improvement over existing practice. This situation often makes it difficult to obtain good valid patents for improved processes, especially in countries where it is necessary to convince the Patent Office examiner that the invention is not only new but also possesses subject matter.

The fluid solids technique provides a good example for consideration. The first commercially significant catalytic cracking process was the Houdry fixed bed. This can be regarded as basic but possessed of very real practical disadvantages. These were solved by the application of the fluid solids technique, and a second basic patent structure was set up. Branching off the same stem, however, was the moving-bed technique, and a specialized patent structure built up around this also. So far as the fluid technique was concerned, its great commercial success led to rapid development or process improvements and operating tricks, each of real commercial significance. The knowledge that competitors were working on the same lines led to the filing of many patents on any promising advance in order to get in first. Similarly, the technique was tried out in different applications. These normally would have some specific requirements peculiar to the process, so that in addition to the predominating patent structure on the fluid solids technique generally and on fluid catalytic cracking, there are separate structures, for example, on the Fischer–Tropsch synthesis, fluid hydroforming, fluid coking, and a number of chemical reactions, such as the production of phthalic anhydride.

Associated naturally with process research is the field of catalyst development. If solvent extraction is ignored, which volumewise is not of great importance, virtually all significant modern process developments involve catalytic after-treatment of virgin or cracked petroleum fractions. One can say, for example, that catalytic cracking of gas oil for high octane gasoline, catalytic reforming of naphtha for the same purpose, and catalytic desulphurization of distillates generally represent quantitatively between them the most important upgrading processes currently in use.

With refining economics as sensitive as they are, there is obviously a considerable inducement for catalyst improvement to give even relatively small improvements in product yield or quality, or, in the case of the more expensive catalysts, to cheapen the basic catalyst cost. The potential pay-off is quite high, and this is reflected by the amount of work currently expended by major oil companies on catalyst development. Heavy chemical manufacturers who are suppliers of catalyst to the oil industry also work intensively in this field.

The mechanism of catalysis in many of the currently operated processes is by no means as well understood as it might be, and for this reason again it is frequently difficult to obtain reliable and valid patents on catalyst improvements. For example, a new and undoubtedly improved catalyst may have a different pore size distribution from the old catalyst. The

inventor may believe this to be the critical factor and frame his claims accordingly, whereas the real reason for the improved performance is some modification in crystal structure. Broadly speaking, catalyst development covers the same pattern as process development, and the same resultant overlapping ensues.

As an example, in the three main processes already referred to, catalytic cracking catalysts are now almost entirely synthetic silica–alumina gels, natural clay-based catalysts being rarely used. Cobalt molybdate on alumina is used practically exclusively for desulphurization. Platinum or molybdena type catalysts are used for catalytic reforming. With so few variables to play with it seems almost inevitable that there should be some conflict. It may even be wondered how patentable differences may be developed in such a limited field. Detailed examination shows a whole variety of respects in which valuable and patentable improvements may be made: spray-drying or other techniques to produce microspheroidal fluid catalyst; catalyst bases of controlled pore size and surface area; catalyst bases of desirable physical characteristics produced by specific precipitation or gelation techniques; optimum methods of dispersing the active principle on the base. All of these provide avenues of investigation which may be rewarded by commercially-useful discoveries, which, in turn, may be capitalized by patenting them.

A further line of activity which is likely to develop in a similar way to process research is that of petroleum chemicals. At present this may be regarded as relatively new compared with conventional or primary petroleum products and is also of much wider potential scope. Different organizations have tended to follow their own particular preference in the petroleum chemicals in which they have specialized, and as yet there is no overlapping of the same nature as exists in the basic petroleum processing field. However, expansion in this type of activity is very rapid, and the fundamentals are likely to be common to all operators. Petroleum fractions are steam-cracked or otherwise treated to give olefins, diolefins, and aromatics as raw materials for further processing. Alternatively, acetylenes or other reactive molecules may be produced. From that stage the two main lines of further processing are either polymerization to produce rubbers or plastics—Butyl, Buna, Polythene, polypropylene, etc.—or to produce a range of oxygenated products, ranging from primary alcohols as the simplest example, through glycols and polyglycols, to quite elaborate syntheses, such as that of glycerol.

By contrast, additives and speciality products present a rather different picture. The scope for additive development embraces almost the whole of organic chemistry, and there is a tendency for each company to adopt some field or class of compound in which it has faith, and to develop that class quite thoroughly without overlapping into the work of competitors. The outstanding exception to this general rule is tetraethyl lead, for which no adequate substitute has yet been developed. The advantages of good patent protection when a discovery of this nature is made will be apparent. However, lubricant additives, such as detergents based on metal phenates or soaps, anti-oxidants of phenolic or amine type, V.I. improvers comprising polymerized olefins or unsaturated esters, sulphurized, phosphorized, or halogenated materials for extreme pressure service, offer ample scope for detailed development without marked patent conflict.

To say the same thing in a different way, additives, greases, and specialities work can be extremely fruitful in patentable ideas, both in the development of new materials and in the discovery of synergistic combinations of old ones. Unless this is appreciated, there is a risk in an integrated research organization that a disproportionately high percentage of its total patent holdings may be of this type.

The general question of the recognition of patentable inventions when they have been made, and the policy principles on which they should be filed, is of primary importance. Most oil companies are fairly liberal in their patent filing, and there is a growing tendency (admittedly shared with other large-scale industry) for them to maintain their own domestic patent departments, rather than to rely on the services of private patent agents, except in countries other than their main centre of operations.

The organization and method of operation of a patent department will depend largely on the size of the concern. Ignoring contract and licensing matters, the fundamental duties of the department are the drafting, filing, and prosecution of patents for inventions made within the organization. An additional important duty is the scrutiny of competitors' patents as they issue, both as a potential source of useful information for the research department and with a view to their possible effect on the organization's own operations. If they are uncomfortably close or if infringement seems possible, the question of opposition to the grant must be considered. An analogous service consists of specific patent searches in various fields as a preliminary, for example, to the institution of a new research programme or the installation of a new refinery unit.

At one end of the scale the department may consist of a patent agent with one or two technical assistants and appropriate clerical and records staff. The work is allocated as convenient, and all the technical members of the department should develop into all-rounders. At the other extreme, a really large organization filing several hundred patents a year may be set up in the conventional pyramidal structure, with sections and groups operating under an administrative head. These groups will consist of technical patent men specializing in some sub-division of the company's activities, such as lubricants,

refinery processes, chemicals, etc. Where a separate group is concerned with patent searching, it is frequently associated with the library, which may itself come under the administrative control of the patent department. It has also been found very valuable, particularly in a large organization, to have a member of each of the major sub-divisions of the research laboratories specifically appointed to act as liaison between his own department and the patent department.

The recognition and development of patentable ideas may be either active or passive. In the passive approach a research worker or his superior will inform the patent department that he has made an invention worth patenting and the department will then take the necessary action. This should give adequate protection for the more important developments arising from the planned research programme. In the active approach, the patent department, through its representatives, is continually urging the research workers to submit any inventive ideas that may occur to them in connexion with the company's business. These ideas, which may or may not arise directly from the research programme, are evaluated by suitable experts and patent applications filed on such of them as appear to merit it. In addition, members of the patent department should regularly attend research meetings, hold discussions with research workers, and critically scrutinize research reports. By this technique, anything of importance in the research programme should be amply covered, together with a number of extraneous ideas.

This deals only with primary filing in the country of origin. The international nature of the oil industry brings the need for wise and selective filing throughout the world. Inadequate foreign filing leads to loss of competitive position, whereas over-lavishness can be excessively expensive. As a rough estimate one might say that the first cost of obtaining a patent for one invention in forty countries would be of the order of £2500. The total cost of keeping it alive in those forty countries for a period of ten years would probably be about £6000. A large company may file as many as 500 primary patent applications in a year, so that the need for selectivity in its foreign filing is apparent.

Two main methods are commonly used. The first is largely empirical and involves the evaluation of each case by a committee representing the relevant divisions of the company's activities—research, refining, marketing, etc. This committee makes individual recommendations for the foreign filing of each individual case. The second, and somewhat more elaborate method, involves the classification of countries by their relative importance in various fields of activity—catalytic cracking, fluid coking, Fischer–Tropsch synthesis, etc.—and the grading of each patent application according to its technical importance. To illustrate, two cases on catalytic cracking may be rated respectively of basic value and of minor technical value. The first will be filed in a predetermined series of, say, a dozen countries laid down as those in which basic cracking patents should be filed, whereas the second may not be filed abroad at all or at best in the one or two most important countries on the main list.

In considering the whole subject of filing patent applications to cover the fruits of research work, it must be remembered that the object of so doing is twofold. First, there is the protection of the operations of one's own affiliates. Secondly, there is the acquisition of patent assets which may be licensable to others to the advantage of both parties. The licensee obtains an improved process or product, and the licensor receives some material reward which he can set against the cost of his research investment. This leads one logically to the third part of this paper, on patent licensing.

PATENT LICENSING IN THE OIL INDUSTRY

As a background to this section one may state that the general attitude in the oil industry is to be aware of and to respect the presumptively valid patents of competitors. As a corollary to this there is a general willingness for patentees to license their own competitors, and this applies particularly in the field of petroleum processing.

There are two main types of licence, namely exclusive and non-exclusive. The difference between these two is self-explanatory and, for the reasons already dwelt on, the non-exclusive licence is the type almost entirely met with in the oil industry. The rights and information given under the licence may vary greatly from a simple patent immunity with no technical information or knowledge at one extreme to the provision of a finished process with full operating knowledge and performance guarantees at the other. Such variations are best exemplified by considering typical licensing activities in various fields.

Progress in exploration and production mainly involves the development of improved electronic and similar instruments for seismographic work, core analysis, and so forth. The oil companies will not normally wish to manufacture their own instruments, and will generally license some instrument manufacturer to do it for them. Such manufacture is expensive, and the market is limited, and to provide adequate inducement to the manufacturer, such licences may be exclusive for quite a long period, thus providing an exception to the general rule.

Inventions involving health, safety, conservation, etc., are frequently licensed free of royalty, at least so far as the user is concerned. For example, the Pool Analyser developed by the Carter Oil Company, which

involves the application of computer techniques to the evaluation of the potentials of oil reservoirs, was licensed free. Similarly an oil skimmer or effluent treating device whose object was conservation or the avoidance of pollution would normally be made freely available to a refiner who wished to use it. By contrast, however, if an outside manufacturer wished to enter the business of making and selling such devices to the industry he would be expected to pay royalty.

The most important type of licensing activity is probably that concerned with processes. The property being sold here is a finished process and carries with it full know-how and operating information. The licence agreement will be tied to a considerable number of patents which may or may not be listed in the document. Frequently, in order to avoid the patent overlapping already referred to, a process will be licensed jointly by two or more independent companies, the royalty being split in proportion to their respective contributions.

Virtually all the important refining processes currently in use are available on licence. Catalytic cracking, catalytic reforming, hydrodesulphurization, solvent extraction, dewaxing, and de-asphalting processes are all available from a number of licensors, and hence are in a highly competitive market. The situation is possibly best illustrated by a hypothetical example.

Suppose that a refiner wishes to install a catalytic reformer for the production of high-octane gasoline from virgin naphtha. He knows what his feedstock is and the product octane he requires. He will approach a number of contractors and ask them to submit bids. The contractor will approach the licensor oil company or companies whose process it wishes to bid on. From correlations or pilot-plant data the licensor company will provide process design data and estimated yields for the unit designed by the customer. From this the contractor will prepare his detailed engineering design and submit his bid to the customer. The customer will compare the various bids, with particular emphasis on plant cost, royalty component, operating cost, catalyst life, yield, ultimate octane ceiling, etc. Having made his choice, a licence agreement will be signed between him and the licensor oil company.

This agreement will contain firstly a definition of the process to be licensed. The licensee wishes this to be broad enough for him to enjoy to the full the right to operate and modify his process as he finds it expedient. For the same reason, the licence will commonly grant rights under future patents within the licensed field, based, for example, on inventions which may be made up to, say, five years after execution of the agreement. The licensor will accordingly be concerned that the process definition is not so wide as to include within its scope a basically new and more valuable process which may be developed within this five-year period. The definition of the process should thus be such that the licensee is free to incorporate any routine improvements of this type without the need to negotiate a fresh agreement, but not free to use some revolutionary advance without payment of additional royalty.

The licensee, after signing the agreement, will also receive valuable technical information on the licensor's catalytic reforming process. His technical and research men are thus put in a very favourable position in regard to making future developments and improvements. If any such improvements are made, the licensor will wish to be able to make them available to his other licensees, and accordingly the licence agreement will normally contain provisions under which improvements made by any one licensee can be made freely available to all the others.

A point of major interest to both parties is the royalty payment. Since the thought of paying royalty to a competitor is generally regarded with disfavour, and since this opinion is normally based on instinctive misconceptions, it is worth while pausing for a time to look at the general principle of royalty payment more objectively. The licensee is a free purchaser on an open and competitive market. The process which is available for licence must represent to him some advantage or saving over existing techniques. In our hypothetical example this means that the selected reforming process must be attractive to him both compared with other octane upgrading techniques, such as catalytic cracking, which may upset his refinery balance, and also compared with competitive reforming processes. The normal basis for estimating royalty rates is a fair sharing between the licensor and the licensee of the saving or benefit which accrues from the use of the licensed process. There are at present a dozen or so different catalytic reforming processes available, mostly using platinum catalyst. In such a situation royalty rates soon find their correct economic level.

Royalty rates may be computed in a number of different ways. For example, the basis may be the financial upgrading of the product, that is to say, the difference between the market value of the raw material and of the finished product. Alternatively, the royalty may be based on the sales price of the product itself or on the capital investment in the plant. For petroleum processes, however, it is usually expressed either as a running royalty in cents per barrel passed through the unit or alternatively, and more commonly, as a paid-up royalty, which is generally based on an assessment of running royalty over a period of seven years and expressed in terms of dollars per daily design barrel.

The licence agreement will also probably contain a " most favoured nation " clause. This means in effect that if in the future the licensor transacts a similar arrangement with another licensee on terms more favourable than those granted to the first

licensee, the first licensee will have the right to get equally favourable terms.

Another condition which is becoming increasingly common is the inclusion of a clause under which the licensor undertakes to protect the licensee from the adverse effects of infringing competition. In other words, if a third party sets up and operates the licensed process without paying royalty to the licensor, he must either sue for infringement or forgo a substantial part or even the whole of his royalty. Similar conditions apply with a financial penalty to the protection of the licensee against an infringement suit brought against him by some other patentee resulting from the operation of the licensed process.

Yet a further condition which is becoming increasingly common is the inclusion in the licence agreement of some form of performance guarantee under which the licensor forfeits a part of his royalty if the process does not operate according to design. In the case under consideration, with a platinum catalyst costing about £5 per lb, guarantees might be given on yield at given octane levels and also on catalyst life, *i.e.* a minimum number of barrels of product at design octane per pound of catalyst.

The general effect of all this is that the best current processes are available to the smallest of operators at a very reasonable cost and without the need for him to support a large and expensive research organization. At the same time, the larger organization which develops the processes knows that it can recover at least a fair share of its expenditure by free negotiation on a competitive market.

Many of the petroleum chemical operations practised by the major oil companies are on a large scale, similar to that of some of the refining operations discussed above. Examples are the manufacture of butadiene, styrene, and *iso*butylene, and of alcohols such as ethanol and *iso*propanol. In these cases it is comparatively rare for a complete process to be available for licence, but a choice will exist for the various stages. In considering butadiene manufacture, for example, the potential customer could choose between several methods for separating his butene feed stream from his original C_4 cut. Several alternative catalysts are available for the dehydrogenation step, all under licence. Finally, there is a wide choice of recovery methods, the two most common being recovery by complex formation and decomposition with cuprous ammonium acetate, and solvent extraction or extractive distillation with furfural. A given commercial plant will consist of a combination of these stages, each being selected on its merits by the licensee. Similarly in alcohol manufacture, the method of hydration of the olefin, *e.g.* strong or weak acid or direct hydration over solid phosphoric acid type catalyst, will have no bearing on the method used for the separation of the ethylene feedstock or the purification of the product ethanol.

It should not be thought, however, that all petroleum chemical processes are of this heterogeneous character. Integrated processes analogous to those discussed under refining are available, especially in the polymer field. Butyl rubber and poly*iso*butylene provide examples of this. The most topical example, however, is polyethylene, for which a surprisingly large number of alternative manufacturing processes is beginning to appear.

The last type of activity to be discussed is the rather miscellaneous field of additives and speciality products, such as greases, compounded lubricants, industrial lubricants, rust preventives, etc. Licensing is very much less common here than in the large-scale processes already discussed. Considering additives first, they are essentially chemical compounds designed to impart some desirable quality or to alleviate some disadvantage of the fuel or lubricant to which they are added. Very few additives are so good that they cannot be matched by some entirely different product developed by a competitor. TEL has already been mentioned as a virtually unique octane upgrader; silicones are outstanding as foam suppressants in lubricating oils. For the rest, poly*iso*olefinic V.I. improvers compete with polymethacrylate types; alkylated polystyrene and wax–naphthalene type pour depressants exist side by side; detergent additives of many different types perform a satisfactory job. The production of such additives is generally concentrated in the major oil companies, who develop their own line, and in chemical or specialist companies trading in additives as such. The result is that most of the smaller consumers and some of the larger are well satisfied to buy their additive requirements on the open market. Exceptions exist, as always, and licences have been granted, for example, for the use of certain attractively priced and available glycols as anti-icing additives in gasoline and for the manufacture of certain zinc thiophosphate derivatives as lubricating oil additives.

Greases and elaborately compounded blends tend to follow the same pattern, each manufacturer pursuing his own specialized line. When a major advance is made, however, licensing is not uncommon, and the manufacture of lithium-based grease, first patented in 1940, has been widely licensed.

In contrast with the process type of licence already discussed, licences for additives and specialities will commonly confer only a patent immunity, and the royalty rate will be assessed as a percentage of the sales price of the product.

The foregoing is a necessarily brief outline of the way in which patent licensing works in the oil industry. The overall pattern may perhaps be summarized by visualizing a new organization setting up a grass-roots refinery and intending to turn out a full range of products up to and including premium motor oils. Safety, health, and anti-pollution measures incor-

porated in the refinery design will probably be made available free of cost. For its special process units there will be the choice of two types of catalytic cracking, a dozen or so catalytic reforming processes, and sixteen hydrodesulphurization processes. There will also be an adequate variety of processes available for the lubricating oil plant. A wide range of additives will be available once again under the competitive market conditions of low price and good customer service. Sensible and intelligent application of the patent system, as shown by this situation, is significantly responsible for the rapid progress and development of the industry.

CONCLUSION

This paper started by giving an extremely general summary of the patent system as it exists today in the majority of the more important countries in the world. From this it went on to consider the pattern of research and development in the oil industry, and as a consequence the types of patent structure which have been built up. The third section dealt with the use which the industry makes of its patents and the way in which it applies them to simplify some of its problems.

Speaking now quite generally, it is considered that the patent system as it has developed is an excellent thing and encourages research, development, and general industrial progress, with freedom from the fear that one's technological achievements may be pirated. These advantages are especially marked in the case of large-scale industry, where significant research programmes may cost an enormous amount of money and where in the absence of any patent system there would be the strongest possible inducement to carry out one's work under the strictest conditions of secrecy.

While, as stated above, this principle is a perfectly general one, the oil industry is an excellent example of its application.

The overlapping of patents which inevitably follows from the closely parallel lines on which research is carried out has been already referred to. This causes quite a number of oppositions to the grant of patents and applications to various patent offices for the revocation of patents, together with so-called "interferences" in the U.S.A. Such conflicts occur normally only in what may be called the "prosecution" stages of a patent, and represent the normal desire of any large organization to achieve a good competitive position. Thus it is quite the normal thing to carry out research work on a process known to be under development by a competitor, with the positive object of obtaining one or more useful patents in that field which may provide useful bargaining rights if at any future date one should wish to take a licence.

In contrast to the conflict which may arise during the actual prosecution stages of a patent, the liberal licensing policy which has already been discussed means that actual litigation in the form of infringement actions, etc., are surprisingly rare. One additional factor which also contributes to this state of affairs is the exceptionally high cost of patent litigation and the uncertainty in many cases of the ultimate result.

What all of this adds up to is that the oil industry has taken a sane and sensible approach to the patent system, and has applied it to its own best advantage. Undoubtedly, this approach, coupled with the excellent brains which the industry has been able to attract, has contributed very materially to the outstanding progress which it has made over the hundred years or so of its life.

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DISCUSSION

Fyfe Gillies: Dr Tyson, in his opening remarks, attempted subtly to anticipate any criticism that may follow by referring to the different points of view which patent people (even in the same organization) hold on the same question. This may well be true, but I found myself in substantial agreement with virtually every word he said.

Therefore the comments which I would like to put forward relate almost exclusively to a subject which Dr Tyson has not touched upon, but on which I think he may in reply have something to say which ought to be of great interest. The subject is the international protection of patent rights, which is obviously of the greatest importance to the largest international industry in the world. Dr Tyson has truly said that the concept of a world patent is a myth, but there is an international régime on patents which dates back to the 1880s, and which has created a series of International Conventions, the operation of which has resulted in a quite extensive unification of national industrial property laws.

In the early days, when this international régime was being worked out, the bodies carrying on the work were composed of businessmen, scientists, and lawyers. To-day they are composed largely of lawyers. This is a situation which is quite reasonable in a time of slow progress towards narrowly defined objectives. The position to-day is very different, for in the next ten years or so there is likely to be a whole series of decisions of very great importance to industry, and it seems to me to be highly desirable that the businessmen and the scientists should again take an active interest in these questions.

The International Conventions are amended from time to time at Diplomatic Conferences. The next Diplomatic Conference, the first for 20 years, is being held in

Lisbon towards the end of 1957. This means that at the present time the appropriate government departments in something of the order of 50 countries are thinking about Industrial Property (which incidentally is a generic term used to include patents, trade marks, and designs). So it is at a time when they are receptive to ideas.

The second point is that the Council of Europe has set up a committee of experts to study Europeanization of Patents. The activities of this committee have already resulted in the signing of two new patent conventions, one on a common classification for subject matter, the other on procedural formalities. The committee is now working on the concept of a European patent. It is very interesting to ask oneself a question. The theory of a European patent is that one can get for a small fee, say £50, one patent which will cover the whole of Western Europe. Would one necessarily like this if it meant that one's competitors could secure 20 patents covering the whole of Europe for £1000?

The third matter is perhaps the most serious patent problem on the international level to-day. It may be perhaps desirable to give an example. In the U.K., before the war, a patent had normally to be accepted 18 months after the first filing; a year is allowed after filing a provisional specification to develop the invention and to file a complete specification. In the normal course of events, therefore, a patent would be accepted six months after filing the complete specification. In the "examining" patent offices of the world to-day, and they include the U.K., Germany, Holland, Scandinavia, and the U.S.A., there are very serious delays over the grant of patents due to a series of factors such as the build-up of wartime arrears, the complexities of inventions in new arts and sciences, the increase in the number of applications being filed, and the serious shortage of scientific staff in the patent offices. To-day it is by no means unusual that the time from filing the complete specification to the time when it is accepted may be, for example, four years. In the U.K. a patent is granted for 16 years, so 25 per cent of the total period of the grant may have expired before the patentee is entitled to enforce his monopoly. If one looks at it from the industrialist's side, he can, in all good faith, have an expensive plant designed, built, possibly have it in operation for a couple of years, and then find that a competitor holds an adverse patent and is therefore in a position to stop his operations or to charge a penal royalty in consideration of allowing them to continue.

The fourth point relates to the proposed Customs Union for Western Europe and the Free Trade area to which the U.K. may very well be a party in the near future. If one takes as an example a series of patent licences under which a patentee grants a licence to Mr A in the U.K., to Mr B in France, to Mr C in Germany, and so forth, each licence provides that the right to sell should be restricted to the country for which it is granted. Now, if there is a Customs Union, in theory the goods should pass freely across frontiers, but in the example given the patent system is itself creating an artificial barrier which operates against the basic theory of a Customs Union. There is no ready-made solution yet in sight, but it is another problem which industry must face in the near future.

The basic point I wish to stress is that the next decade is an important one, and that the businessmen and the scientists really ought to devote some time to developing the industrial considerations which should dictate the answers to some of the problems outlined. This is especially true of the oil industry with its vast international experience.

Dr J. T. Tyson: I would not reply to any of Mr Gillies' specific points, because he is well known as a specialist in this field and is one of the major proponents for Europeanization of patents. However, I would support his closing remark, namely the suggestion that scientists and businessmen should get together more on this subject. Patents are only one facet of what is collectively known as industrial property. The type of organization to which Mr Gillies was referring is the International Association for the Protection of Industrial Property, which is a worldwide organization. There is also the Trade Marks, Designs, and Patents Federation, whose activities are concerned with British interests. Such bodies have as their function the ensuring that worldwide industrial property is fairly treated, and that the owner of it gets a fair deal. The main purpose of my paper, and what Mr Gillies has also been making quite clear, is that this form of industrial property is intangible; it is not substantial, one cannot handle it or feel it, but it is still there, and it is something with a real value. Like other property, it needs protection, and in this, some form of international co-operation is needed.

H. I. Downes: In dealing with abuse of monopoly, Dr Tyson made the point that while there has been a minority in the past that has howled about abuse of the patent system, notably by big business, to-day it is practically impossible to have abuse of monopolies, so much has the law been tightened. As thus stated, I would not quarrel with his proposition, but perhaps, and I believe unwittingly, he left open the implication that if there were a chance, we would do all we could; I do not think such an implication was in his mind. From my own experience of the oil industry, I have seen indeed very little evidence to support any charge of abuse of monopoly. I have to study patents of many competitors, and know something of the patent activities of my own organization. The idea of patents being taken out to suppress progress and to see that there is no technical development in a particular field is not a factor in the oil industry's thinking.

Turning to the remarks on patent licences, I may be voicing quite a personal reaction, but I thought that to some people there may be a feeling that licensing of patents was a dominating factor in the oil industry, overshadowing the extent to which patents were taken out to protect manufacturing interests. It is a matter on which I have never seen any statistics, and I would like to know whether the author has got anything on that point. How far do we in the oil industry take out patents to protect our business, our manufacturing or marketing operations, and how far do we take them out for licensing purposes? They are both equally legitimate, and no doubt in quite a few cases patents are taken out both to protect the business and to licence.

Mr Gillies observed that we are amongst the greatest of the international industries and our patent stake is international. If there are shortcomings in patent systems, if there are delays, hardships, unfair practices, we stand to suffer as much as any industry. Yet, as an industry, we have not got our own forum for expressing an industry viewpoint. If we feel that delays ought to be cut down or this or that ought to be done, there is no official expression of viewpoint within the industry as such. I throw out the thought as to whether the IP ought to play a more active role, and have some voice in the thinking which is now going on with a view to improving the patent system as a whole; for instance, the suggestion to create an International Patent Search Office may merit oil industry comment. At the moment,

some of us belong to a Committee, largely composed of industrialists, which meets somewhat informally to discuss such matters, but this body is not truly representative of the oil industry.

Dr J. T. Tyson: In regard to the question of abuse of monopoly, there are quite a number of different types of monopoly. There is the legal State monopoly, set up by statute; there is the monopoly of the concern which has just got too big, and can suppress competition in other ways if it wishes; there is, if one cares to look at it in a rather specialized way, the monopoly of the film star or the artist who can produce something which no one else can produce, and is therefore the sole source of his own particular product, and can impose his own terms on it. The main point, however, is this. Any monopoly, quality, or phenomenon is capable of being abused, and the form of monopoly which is least susceptible to abuse is the patent monopoly, one of the reasons for that being the way in which it is set up by Statute. That is just a background fact. At the same time, I would agree with Mr Downes that, in my own experience, I have not come up against any apparent tendency in dealings with my colleagues and competitors in the oil industry in the direction of abuse of monopoly.

I hope that the impression that patents should be filed actively for the purpose of licensing them was not too widely read into the paper. I think that in the first instance one takes out a patent for the protection of one's own operations and those of one's affiliates. That is, unless one happens to be a professional inventor who wishes to sell his patents, or an organization whose stock in trade is the development of processes to sell to other operating companies. However, if one is in an integrated set-up, covering research, production, refining, and marketing, one's main interest is to one's own affiliates, and to their own operations, and one will wish to devise processes and operations which they can use economically and attractively. Having done that, it will then be clear that, having developed those processes for one's own use, if one can persuade a competitor to use those same processes and pay a reasonable price for them, that will be to one's own advantage as well as to his.

Accordingly, I would say that in this integrated type of industry the filing and prosecuting of patents with the primary object of licensing is wrong, but that whenever one files a patent, or builds up a patent structure to cover some operation, one should not ignore the possibility that it may be to the benefit of oneself and one's competitors if that particular operation can be made available on licence.

In regard to Mr Downes' last point, about the IP getting directly involved in any of this international negotiation, I would not like to give an opinion without thinking it over. A comment in passing is that it does seem that the more different organizations get involved through representatives in this type of negotiation, the more distant becomes the hope of getting anything actually done.

L. H. A. Holmes: I had contacts some years ago with the type of organization that Dr Tyson mentioned, the type that is concerned with licensing patents. Its sole business in life was doing that, and the tendency seemed to me to be that we were flooded with a whole variety of patents for trifling inventions. We had the feeling that these things were not valid at all, and I wonder whether the author could give any figures on whether the validity of these has ever been challenged.

Dr J. T. Tyson: I can assure the last speaker that being troubled with a flood of trifling inventions is not limited to the type of organization which specializes in licensing processes.

As far as validity is concerned, that is not an easy question. Undoubtedly a lot of patents are obviously not valid. I think I am right in saying that about 25,000 British patents are issued in a year. That is an order of magnitude. In a given year, there will be about five patent cases in the Courts, in which validity will be a matter of concern, and those will roughly go 50–50, so that about half will be held valid, and half invalid. I believe the reason is that patent litigation is extremely expensive, and it is only the marginal cases that are likely to get as far as the Courts. If a patent is manifestly invalid, then the patentee will not attempt to enforce it, and if a patent is manifestly valid, then the chances are against someone attempting flagrantly to infringe it. Perhaps those figures do support the philosophy that it is only the marginal cases that reach the Courts. There are, however, not enough of them to justify any statistician sitting down and giving a balanced and accurate analysis. There is admittedly a school of thought which takes the attitude that the majority of patents are invalid. In the sense that they are documents which are made by fallible human beings, and subject to attack on a wide variety of grounds, there may be some truth in that. One can, for example, in the U.S.A., also have a hostile court. A judge in the U.S.A. once delivered himself of the memorable statement, "The only valid patent in this country is one that hasn't been brought in front of this court."

E. H. G. Sargent: Having regard to Dr Tyson's remarks on oil additive patents in the petroleum industry, would he not think it better if the Comptroller had greater powers to reject any patent application on the grounds that it was not really a valid patent, *i.e.* that this patent would not be defendable in Court and therefore should not be granted?

The second point I would raise is the case of chemical patents. Does Dr Tyson think that the old German practice of requiring samples and specimens with an application was a very good one? One often reads a patent where 700 or 800 different compounds are claimed. I think it very doubtful if the claimants have really made these compounds, let alone tested them as exhaustively as they suggest, and consequently I think it would be a good thing if such patents were disallowed, except in so far as they can really prove that every compound claimed works.

In the new patent laws the Comptroller has in theory greater powers to revoke a patent application during the three months period. Does the author feel that these powers are to some extent illusory, particularly when obviousness is claimed for a ground of revocation, and would it not be better if the Comptroller's powers were strengthened and made clearer?

Dr J. T. Tyson: Once again, there are arguments in favour and arguments against. All men are human and fallible, patent office examiners not excepted; a man who sits in an office is going to find it much more difficult to appreciate the scintilla of invention in something which may represent a very real technical advance. That advance may be quite manifest to the technical man concerned, working on a refinery or in a laboratory, but rather boring and unimpressive when put on paper. If one gives the Patent Office greater powers to reject patents on grounds of invalidity, which means in effect

lack of invention, on the one hand, one would probably have fewer patents, which might be regarded as a good thing; on the other hand, there would be an increased risk that a good invention might be thrown out by the Office simply because the patentee had failed to put his case over adequately.

In regard to samples, the persons best qualified to comment on this would be the patent office examiners present. Samples used to be filable at the British Office, but the practice was stopped. It was possibly because there was a loophole in the law, in that one was enabled sometimes to bring in descriptive matter which was not present in the specification as filed, and it also caused some inconvenience to examiners when the invention involved something of an exceptionally objectionable, dangerous, explosive, or generally noxious character. Once again, there are things to be said on both sides.

The last question was whether or not the Comptroller's increased powers to revoke a patent are illusory. I would say this: they are not strong. The argument is to some extent the same as that on which we started, namely the question of validity and to what extent the examiner should be given the right to get up and say dogmatically, "This is no invention! This is obvious," when a number of highly-skilled technical men may disagree on that point. This is not so much a question of arguing present and past practice in the British Office, as arguing for the practices in various foreign offices, especially the American and German. There are certainly times, depending on the progress of one's own case and those of one's competitors, when one feels one way, and times when one feels rather strongly the other.

J. M. Wilson: There does seem to be a paradox in something which is commonly held when one talks about patents. Dr Tyson states in his paper that one of the advantages in taking out a patent is that it is an inducement to carry out research and development and allows a company to tell the public the results of that research, whereas it seems to me that the paradox is that as soon as one differentiates, as everyone does, between a patent and "know-how," one is implying that one is not publishing everything.

Dr J. T. Tyson: That is a very good point. The immediate and facile answer is this, that if one is undertaking a new and fairly important development, one will obviously file patent applications at the earliest possible stage in order to get the earliest possible date. That patent will cover, or should cover, the best way of doing the thing as one then knows it. As this particular development progresses, one will probably file some supplementary applications which will contain fuller details. However, after that stage has been reached, one will continue to develop the process to its optimum actual commercial embodiment, and that will involve "know-how" which has been acquired, as the result of trial and error and experiment, after the date of the last patent specification. Once one has filed a patent specification, nothing more can be put in it, and not only, of course, is one under no obligation to go on filing patent specifications for ever, which in any case would be an expensive proposition, but a lot of this "know-how" is, in fact, not patentable in itself over and above the basic patent structure.

J. M. Wilson: What was really meant was that often enough this stops any other means of publication. Where there was a chance of licensing a process, one would not want to publish further information which, although not patentable, might be vital to the process.

Dr J. T. Tyson: That would depend entirely on the amount of confidence one had in the strength of one's patent structure. If one had perfect confidence in it, one would have nothing whatsoever to lose by publishing everything one liked.

E. Le Q. Herbert: I would have thought that if one had that sense of fallibility in a patent, and one is wanting to license, then the more one publishes the better.

R. C. Porten: Is it not also the practice that people sometimes say that they use a substance, A, B, C, or D, A, B, and C being put in merely as a disguise, D being the true one? In other words, matter which has no relevance is included in the specification or patent.

Dr J. T. Tyson: The point may be accurate, but the assumption of the motive is not. A patent will intentionally be framed as widely as possible to cover A, B, C, or D, not to fool the public so that it does not know which is which, but simply because, for all one knows, assuming one uses A oneself, B, C, and D may form a most fruitful field for detailed research by a competitor, and one wishes to cover the invention quite widely. That is the basic motive of width of disclosure, width of the range of the various starting materials, and so forth. It would be pleasant if one thought one could get away with everything, and merely put up a patent to fool the public, but it is a very difficult thing to do satisfactorily. If the invention as claimed does not work, the patent will be invalidated in any case; if B, C, and D are useless, and merely put in as a smoke-screen, it will have the effect of invalidating the patent even as it affects A, especially if it could be shown or even suspected that the whole thing had been done in bad faith.

V. Biske: There seem to be different approaches possible to the subject of opposition proceedings. If A has a patent and then B takes out a patent covering a somewhat similar field and which, in the opinion of A, overlaps with A's patent there appear to be two courses possible. A can enter an opposition, which could result in B amending his specification so as to turn what was an invalid patent into a valid one, or else A can sit back and do nothing unless B's patent becomes a nuisance, when he can move for its revocation as invalid on the ground of prior publication. Which course would Dr Tyson favour?

Dr J. T. Tyson: There are so many variants possible. There is the case, for example, where B's patent is a nuisance because of some overlapping with A's patent, and the effect of opposition might be to cause him to narrow down and validate it, but by narrowing it there will no longer be the overlap. Then there is the point where B's claim hits right at the heart of A's patent, so that any form of narrowing down can still leave it 100 per cent relevant, and the only useful result of an opposition would be to get B's patent positively and finally rejected, because amendment or narrowing of any description will still leave it highly pertinent. One has to consider each case on its merits, bearing that sort of factor in mind, and assuming one's chance of getting the patent revoked. One always has knowledge that if it came up in court, all the arguments one could put in front of the Comptroller would be equally applicable and would carry greater weight because the Courts could attach much more significant importance to them. Now, taking the rather specific patent practice angle of trying to oppose on a basis of prior claiming, my organiza-

tion recently had an opposition on that basis, and the result of it was rather inconclusive. This is an evasive answer to the question, but I personally would try very hard to invalidate B's patent on other grounds and not to rely on the rather technical point of prior claiming *per se*.

J. M. Soesan: May I suggest that the real advantage of oppositions, as against ignoring the other man's patent, is that in the case of opposition, once it has been settled, one knows where one stands. In the case of ignoring the other man's patent, in five or ten years' time one might be faced with that patent, one might have lost sight of the possible grounds for opposition, and one might have to respect a patent which at present could be opposed. That has actually occurred on several occasions.

Dr Tyson is Manager of the Patents and Contracts Department of one of the units of the oil industry. It is not universal to find that licensing and patents are put under one management, and I would like to have the author's views on the advantages and disadvantages, if any, of having licensing and patents under the same management.

Dr J. T. Tyson: I cannot think of any disadvantages. The advantages are that one has two types of operation both concerned with industrial property. One side of the department is creating, or converting, abstract research results into industrial property, and the other side is concerned with the sale, transfer, or, more broadly, the general handling of industrial property to the advantage of the organization. It is a great advantage, in my opinion, if those two operations can be directed through one single source. If one looks at the administrative structure of any organization, no matter how it is set up, and however separate its licensing and similar activities may seem to be from the patent department, one will find sooner or later that one comes to some common point of administration. The effect of this is much the same as having a single integrated department, the real difference being that the common point of administration may have other responsibilities, which will mean that it cannot give enough time to co-ordinating those two sides of the business.

J. Romney: We have heard something about the integrity of big business, and I am disinclined to challenge it, but can Dr Tyson tell us what real chance a small company or an individual, owning a perfectly valid patent, has of defending it against infringement by a wealthy and determined company. He did mention an international protection organization; would such an organization take a hand, bearing in mind that one of its principal subscribers is likely to be the wealthy company in question?

There was some mention of the possible use of patents for scotching technical development. I heard a story once about a patent for a practically permanent match. This patent was bought up by the match industry, and squashed, which was obviously not in the public interest. Would it be possible in such a case for governments to step in and refuse to allow that patent to be bought and suppressed?

Finally, is a patent a capital asset? If a man had a patent which was worth, say, £50,000, would it pay him better, from the Income Tax point of view, to sell it for £50,000, or collect £5000 a year royalties for ten years?

Dr J. T. Tyson: The everlasting match last appeared in print in *The Times* about 1946, in very much the terms in which we have just heard about it, of the wicked monopoly interests suppressing this invention of monumental advantage to the human race. I was then working with a firm of private patent agents. We had a client who could be regarded as one of the small men mentioned in the first part of the question. However, he did know something about patents, and he came round and said, "Look, if there is something in this everlasting match, I know it is complete nonsense that it can be suppressed, because the patents must all be lapsed and free now, and if there is anything in this, I am going to make it and sell it." Undoubtedly nothing or nobody could have stopped him from doing that by normal or legitimate means. Correspondents still write of this wonderful everlasting match, which is an ultimate ideal. Presumably one needs only one for a lifetime. I made a patent search, and an everlasting match consists of an object like a Roman candle, with a very slow burning mixture, which is impregnated with a striking material of the same nature as a match head. When one strikes it on a surface like a match box, it bursts into a feeble glow, and one can light things in the same way that one would with a tinder-box or similar device; it can then be blown out and it is ready to be lit again. In fact, one can get about twenty minutes worth of glow out of this device. Nevertheless, I am regretfully forced to admit that, in regard to patent conflict between a very rich and a very poor organization, the remark made by a judge does seem to apply, "The Courts of Law are open to all, just like the doors of the Ritz Hotel."

L. H. A. Holmes: When I was in a patent agent's office, I went to a demonstration of an everlasting match at the Carlton Hotel, and it was a nitrocellulose composition with some diluents in it to slow down the speed of reaction. It did burn for twenty minutes, but when one blew it out one was almost asphyxiated by fumes of oxides of nitrogen.

V. Biske: Searches are troublesome and tedious. A procedure which seems attractive, especially for the smaller organization, is to make a fairly superficial search and, if no anticipation is found, to prepare and file the complete specification. The Patent Office will, in any case, make a search and, should the result of this show anticipation, then even if suitable amendment is impracticable and the application has to be abandoned, the fees thus lost will be considerably less than the cost of a thorough search in the first place. Does Dr Tyson see any disadvantage in such a course?

Dr J. T. Tyson: The argument is absolutely sound. The problem is whether or not one wants the result of the search rapidly, and what one wants it for. Obviously, if one waits for the Patent Office to do the search, one has to wait until one's turn comes round. If the motive of the search is to decide whether or not it is worth filing a patent application, then I would agree fully with this line of approach. If, on the other hand, the motive of the search is to decide whether or not a certain line of development or research is worth going into, then the answer is required more quickly than could be obtained by that particular route. One can get it more quickly by going to one of those admirable organizations set up to provide that sort of service.

C. G. Wickham: There have been one or two questions this evening about whether one obtains a patent to preserve a monopoly or to license. Of course, one can never answer that question until after the patent has run out,

when one can look back and say what happened to it. However, the question raises the basic query of what a patent really is. A patent was envisaged centuries ago as a grant of monopoly; it is defined in the statutes of the U.K. as a grant of monopoly, and most people think of it in this way. Yet half the time it is not used in a monopoly sense at all. It is, in fact, simply the elementary and equitable right to handle one's own technical developments in the way one thinks best, whether it be to protect one's own activities, to license, or whatever the course of events might demand.

I think that patents are coming more and more to be thought of in this way. In this era, with industries spending vast amounts on research, patents provide the only way in which a company spending money on research can keep a control over the results. I like to think of patents not so much as a means of preserving a monopoly, or as something that one has to decide whether one is going to license or not, but as a way of putting a tag on one's own developments and so helping to justify the continued expense on the research that is necessary to keep to the front of the industry. If patents disappeared, what would happen is that this tag on research results would disappear, and then the research results might soon disappear too. The philosophy that Dr Tyson has expounded in his paper indicates that the oil industry has arrived at an excellent compromise in which, when money is spent on research, it is accepted as a principle that the resulting information is going out throughout the industry, to competitors, and to other industries. It thus benefits everyone, but wherever it goes it bears the originator's tag on it, and so eventually in one way or another, which often cannot be foreseen, it brings a return and justifies the continued research. Consequently an established patent system is of interest to everybody who is associated with research and development; it is almost their charter and guarantee that their research and development are going to continue.

Dr J. T. Tyson: That is almost an alternative aspect to what was said earlier on, that a patent is a way of capitalizing one's research, converting the intangible results of research into something which is an asset, which has a value, which can be identified, and which is equally available to the people who put up the money for the research, as a means of seeing what sort of value they are getting for their money.

E. Le Q. Herbert: It is my pleasure to say to Dr Tyson that he has given us a very wide and informative survey on patents generally and patents in the oil industry. His paper brings home to us the breadth of the whole subject and particularly reminds us of how wide and diversified is the field of petroleum technology to-day, and the field that patent experts have to cover. He has done his best to show how wide that field is, and the onus of the work that falls on these people.

Mr Downes and Mr Gillies mentioned particularly the formation of some international agreement, and Mr Gillies also particularly mentioned this question of lapse of time, which is so vitally important to the oil industry and the petroleum chemical industry. Mr Downes suggested the need for some forum of expression, and wondered whether the IP could possibly do something about it. It is a question which might be considered further, and I would remind all members that through the Council of the IP we have representation on the Parliamentary and Scientific Committee, and if there was any particular question that might profitably be referred to the Committee in this way it could be considered.

I would like to comment on a particular phrase used by Mr Gillies, who stressed his anxiety regarding the need for scientists and businessmen to pay more attention and take more interest in these vital matters. Certainly in the past years that was probably quite justified, but I hope that in the petroleum industry, and in particular the petroleum chemical industry, now and certainly in the years to come, the two terms will become more and more synonymous.

Underlying his story are the large sums which the oil industry and various process and design engineering concerns spend annually on research to ensure that progress is adequate to meet changing needs and new demands. An important part of the huge sums going into research is reflected in the great diversity of patents. The field is so wide and diverse that a complete survey is virtually impossible.

It is natural and right in the competitive industry which we serve for each organization to try to patent its own discoveries. In this way the competitive position is preserved without detracting from the possibility of co-operative action between individual organizations on matters of common concern. Patent rights, to be useful, need to be respected by competitors, and it is my belief that, broadly speaking, patent rights are in fact respected in the industry, in keeping with the sense of co-operation and goodwill which animates members of the IP.

The meeting then closed with a unanimous vote of thanks to the author.

THE FLASH TEMPERATURE PARAMETER: A CRITERION FOR ASSESSING E.P. PERFORMANCE ON THE FOUR-BALL MACHINE *

By T. B. LANE †

SUMMARY

An expression for the temperature flash occurring in the contact area of the Four-Ball Machine has been derived. For practical purposes it reduces to $W/d^{1\cdot4}$, where W is the applied load and d the wear-scar diameter.

Using Blok's concept, according to which the load-carrying capacity of a lubricant is characterized by a critical temperature for failure, the maximum value of this expression during a test has been designated the "Flash Temperature Parameter." It is easily obtained from the wear–load curve and is regarded as a measure of E.P. performance of an oil.

INTRODUCTION

In discussing the way to use the Four-Ball Machine to evaluate extreme pressure additives, Blok [1] proposed a method designated the "seizure-delay" method. In this method the criterion of performance was the load at which seizure took place at a time $2\frac{1}{2}$ seconds after the starting of the machine; in practice, the load is obtained by interpolation from a seizure-load–time curve.

The development of this test was based on the concept that a lubricant fails when a certain temperature, characteristic of the lubricant and sliding system, is reached. Blok has shown that the load at failure is indicative only of the temperature in the contact area, provided that the bulk temperature of the test balls has not risen appreciably above its starting value, and so this load must be measured shortly after the start.

For many oils the seizure-load–time curve can be established without ambiguity, but for some oils more than one seizure-delay curve (as such curves are called) may be found. As a rule, when this happens the wear–load curve which may be associated with the test rises to its final wear level by a series of steps rather than by a single step. An example of this behaviour is shown in Fig 1.

The existence of more than one seizure-delay curve was described by Blok,[1] who attributed the phenomenon to the inability of the additive to react and demonstrate its lubricating ability until an increase in temperature, produced by a partial seizure, was obtained. From this it follows that there is no way to demonstrate under non-seizing conditions the full protection which the type of lubricant referred to in Fig 1, for example, can give and that partial seizure is an inevitable accompaniment to the test. Criteria of extreme-pressure activity based on seizure load may then quite clearly be unsatisfactory, since seizure may merely be the mechanism which enables the additive to develop its full protection.

The idea that temperature plays an important part in lubrication processes is supported by evidence obtained in the tests referred to above. This is shown in Fig 2, which gives photographs of three wear scars.

It will be seen that the most severe damage occurs on the side of the scar where the upper ball surface slides out of contact. If the wear scar is regarded as a heat source moving over the surface of the upper ball, this damage occurs at the rear or trailing edge of

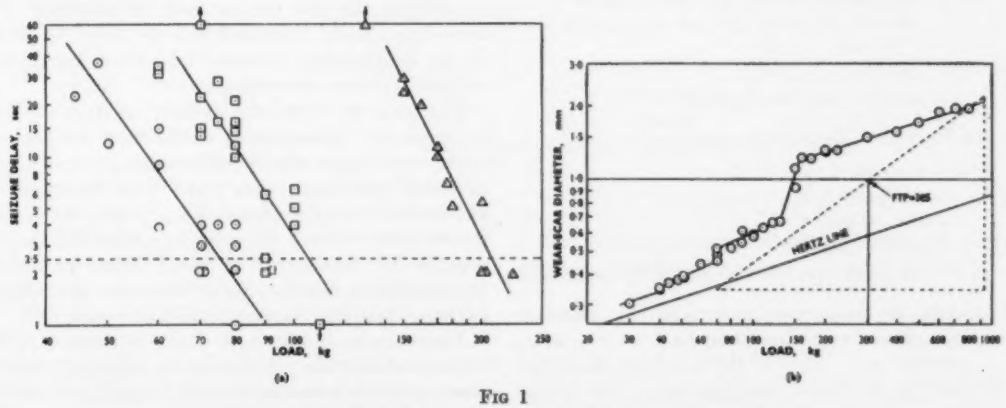


FIG 1

SEIZURE-DELAY AND WEAR–LOAD CURVES FOR PROPRIETARY HYPOID OIL

* MS received 7 December 1956.

† Thornton Research Centre.

the heat source, and it is in this vicinity that the highest temperatures are found according to theory. Thus the seized areas may be associated with high temperatures.

It seemed, therefore, that a measure of the highest temperature in the contact area occurring during a test would be a better way of characterizing the performance of a lubricant than a seizure load the significance of which was uncertain. For this purpose, therefore, an expression for the temperature flash in the contact area has been derived. A similar expression obtained for a slightly different system has been shown by the author [2] to account for the observed behaviour of lubricants on the Two-Ball Machine, and has therefore supported the belief that the characterization of lubricants by a temperature-for-failure is valid.

THEORY

The contact area between the upper ball and a lower ball, together with the frictional heat generated in it under sliding conditions, may be regarded as a uniformly-distributed, circular heat source for the purpose of temperature calculation. The methods of Blok [3] and Jaeger [4] may be followed to derive an expression for the temperature rise of the surface in the heat source.

These authors have shown that the maximum temperature rise ΔT (referred to as temperature-flash in the introduction) on the surface of a semi-infinite, plane body due to a circular heat source is

$$\Delta T = qr/k \quad \text{for a stationary source}$$

or $$\Delta T = \frac{2q}{k}\sqrt{\frac{2ar}{\pi v}} \quad \text{for a source moving with velocity } v \text{ provided that } v > 4a/r.$$

where q = strength of heat source in cal/sq.cm/sec;
r = radius of area of heat source in cm;
v = velocity of heat source in cm/sec;
a = thermal diffusivity $k/\rho c$ in sq.cm/sec;
k = thermal conductivity in cal/sq. cm/sec/°C/cm;
ρ = density in gm/cc;
c = specific heat in cal/gm/°C.

For the Four-Ball Machine elements:

$k = 0{\cdot}1$ cal/sq.cm/sec/°C/cm;
$\rho = 8{\cdot}0$ gm/cc;
$c = 0{\cdot}1$ cal/gm/°C;
$a = 0{\cdot}125$ sq.cm/sec;
$v = 58$ cm/sec (at 1500 rev/min of the machine).

Therefore, for the expression for a moving source to be valid, v must be greater than $4a/r$, or $r > 4a/v$; *i.e.* $r > 0{\cdot}0087$ cm. Thus d, the wear-scar diameter, would need to be greater than 0·17 mm; this is true for the range of loads normally employed on the Four-Ball Machine.

It is reasonable to assume that the temperature existing in the contact is common to both moving and stationary balls, and therefore the frictional heat at any one of the three points of contact in the system must be divided in such a way as to allow this condition to occur. Let a fraction y of this heat enter the upper rotating ball and the remainder x enter the lower stationary ball:

then $$y\left(\frac{2q}{k}\sqrt{\frac{2ar}{\pi v}}\right) = x\left(\frac{qr}{k}\right)$$

and, since $x + y = 1$

$$x = 2\sqrt{\frac{2a}{\pi v}}\Big/\left(2\sqrt{\frac{2a}{\pi v}} + \sqrt{r}\right)$$

Substituting numerical values as appropriate, $x = 0{\cdot}0743/(0{\cdot}0743 + \sqrt{r})$, *i.e.* the quantity of heat entering the lower ball is a function of the wear-scar diameter. The variation of x with r is shown plotted in Fig 3.

The common temperature flash is obtained as follows:

$$\Delta T = xqr/k$$

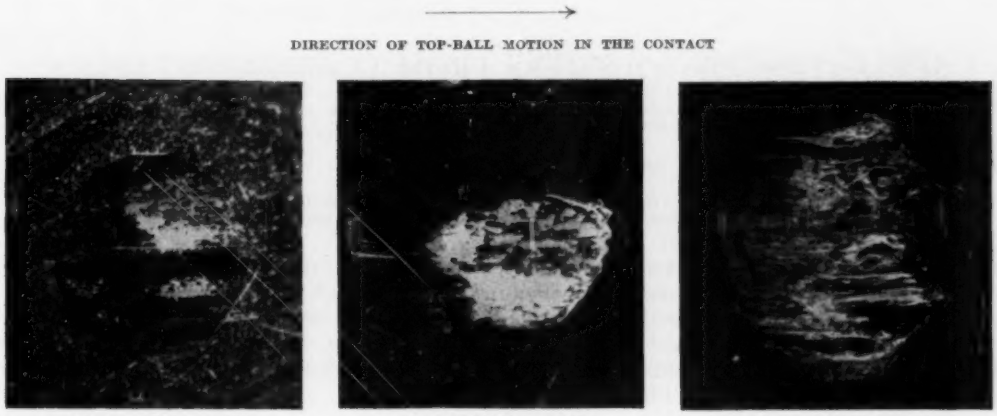
Now the total heat generated $= \pi r^2 q = fWvg/J$ cal/sec, where W is the load in kg (on the ball), f the coefficient of friction, g the acceleration due to gravity, and J the mechanical equivalent of heat.

Thus $$\Delta T = xfWvg/\pi rJk$$
$$= 4{\cdot}31xfW/r\,^{\circ}\mathrm{C}$$

This expression enables the value of the temperature flash to be calculated. The temperature in the contact will, however, be higher than this, since as the test proceeds the bulk temperature of the balls will gradually increase and the temperature flash will be superimposed on the bulk temperature of the balls. It is not easy to allow for the rise in the bulk temperature of the balls, and this difficulty may be overcome by keeping the test run as short as possible. This device, as already explained, was employed by Blok [1] in the development of the "2½-second seizure-load method" for the same reason.

The idea on which the present method is based envisages the measurement of the flash temperature in the contact area when equilibrium has been reached, *i.e.* when wear has ceased, and thus lubrication is satisfactory. Experiments with a variety of oils have shown that the rate of wear has fallen to zero 20 seconds after the start of the run. A test duration of 10 seconds has therefore been chosen as a compromise between these two conflicting requirements.

The expression obtained above involves the coefficient of friction. However, in applying this expression to the assessment of oils in practical cases, it is suggested that this coefficient may be ignored, since temperature is likewise the controlling factor in practice, and lubricant failure will again depend on



(*a*) LOAD 60 kg × 110 (*b*) LOAD 100 kg × 100 (*c*) LOAD 150 kg × 50

FIG 2

TYPES OF WEAR SCAR

the coefficient of friction in the particular application concerned. It may be supposed that if the coefficient of friction varies from one oil to another in the Four-Ball Machine, a similar variation will be found in practice.

For the criterion of performance the expression then reduces to xW/r (ignoring the constant).

This expression may be simplified further by reference to Fig 3, where it is shown that the relationship between x and r is approximately $x \propto r^{-0.4}$. Making this substitution, the criterion of performance becomes $W/r^{1.4}$. Since it is more usual to measure wear-scar diameters than radii and to use the load applied to the machine (W) rather than the load on the individual balls, the expression more appropriately becomes $W/d^{1.4}$ (again ignoring the constants). The value of this expression varies with load throughout a run, and its maximum value, because this represents the most severe condition at which successful lubrication has been established, has been taken as the criterion of performance, and has been designated "The Flash Temperature Parameter." Its value may easily be obtained by a method proposed by Blok.[5] A set square of angle cotan^{-1} 1·4 is placed against the 10-second wear–load curve with the base horizontal (as indicated in Fig 1 (*b*)) and adjusted so that the whole of the curve lies above the hypotenuse of the set square. Since all points on the hypotenuse have equal values of $W/d^{1.4}$, the magnitude of this quantity may be read off directly from the graph paper at the point where the hypotenuse intersects the line $d = 1$ mm.

The usefulness of the Flash Temperature Parameter in assessing gear-lubricant performance is discussed in a forthcoming paper.[6]

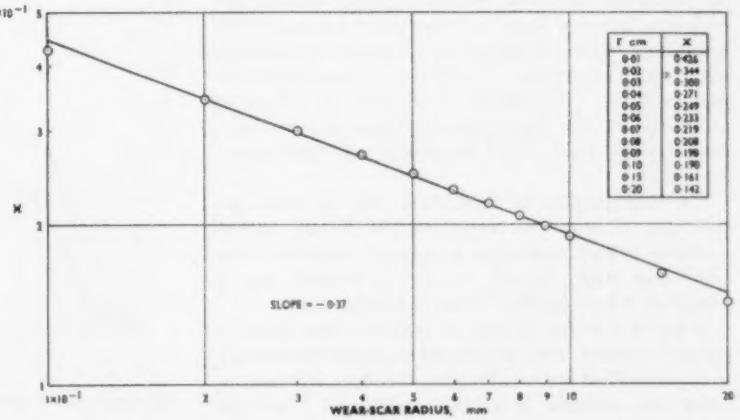


FIG 3

RELATIONSHIP BETWEEN (x) AND WEAR-SCAR RADIUS (r)

ACKNOWLEDGMENT

The author wishes to thank the directors of "Shell" Research Ltd for permission to publish this paper.

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SEPARATION OF POLYMERS FROM LUBRICATING OILS*

By A. GROSZEK†

SUMMARY

Polymers of molecular weight above 10,000 can be separated from blends with mineral oils by chromatography on silica gel. The method is illustrated by the separation of polymethacrylates from mineral oils.

THE separation of high molecular-weight polymers from lubricating oils and similar materials is often impossible by the use of conventional methods involving vacuum distillation and solvent precipitation. Methods depending on vacuum distillation are unsuitable because some constituents of the lubricating oils possess very low vapour pressures and cannot be distilled, even under the conditions of molecular distillation.[1] Moreover, the temperature of the distillation often rises to a level at which the polymer starts to crack. Methods depending on solvent precipitation fail to give polymer free from contaminants, since some materials from the oils are precipitated with the polymers.

Chromatographic techniques have been used by Claesson to separate polymers into fractions possessing different molecular weights.[2] With suitable adsorbents, he found that the adsorption decreases with increasing molecular weight of the polymer and that the rate of adsorption of high molecular-weight substances is low. The effect of the molecular weight of polymers on their adsorption on solids has also been described by Jenckel and Rumbach [3] and by Desreux and Oth.[4]

Chromatography of lubricating oils on silica gel provides an easy and rapid method for the partial isolation of high molecular-weight polymers not contaminated with the oil. Oil-free polymers can be obtained, which facilitates their identification.

When a solution of the oil–polymer mixture in a suitable solvent, such as *n*-heptane, is passed through a column filled with silica gel, the first material to leave the column is oil-free polymer. That the polymer thus separated is not contaminated with any oil was established by determining the properties of the polymers, before they were blended with mineral oils, and again after separation by chromatography from the synthetic blends.

Fig 1 shows the process of elution by *n*-heptane of mineral oil blends containing polymethacrylates A and B having average molecular weights of 15,000 and 20,000 respectively. The column used was of 40 cm in height and 1·5 cm in diameter, packed with 30 g of 50- to 100-mesh silica gel. The weight of each oil blend chromatographed was 5 g dissolved in 10 ml of *n*-heptane, and the elution was carried out by *n*-heptane, 2-ml fractions being collected. The concentration of solute in the successive fractions of eluate increases rapidly at first and subsequently at a much slower rate, with the fractions of eluate containing exclusively polymer. Thus the first 10 to 20 ml

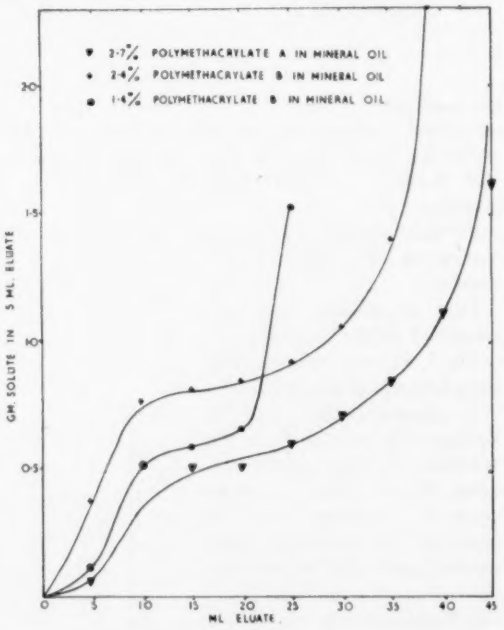

FIG 1

SEPARATION OF POLYMERS BY CHROMATOGRAPHY FROM MINERAL OILS

of the eluates contained oil-free polymer and subsequent fractions mixtures of polymers and oil, the oil content increasing rapidly with the number of fractions. When about 20 to 50 ml of eluates have been collected most of the polymer is separated. For example, for oil containing 2·4 per cent of polymer B, the first 20 ml of eluate contained 57 per cent of the polymer free from oil.

The method described was found suitable for separation of polymers of molecular weight higher than 10,000. For polymers of lower molecular weight

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† Benzole Producers Ltd.

the method fails, since the separated polymer is contaminated with oil.

ACKNOWLEDGMENT

The author wishes to thank the directors of the Benzole Producers Ltd for permission to publish this paper.

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OBITUARY

BASIL RAWDON JACKSON

1892–1957

It is with regret that we record the death on 29 March 1957 of B. R. Jackson, who first became a member of the Institute in 1927.

Basil Rawdon Jackson was born at St John's, Newfoundland in 1892 and passed part of his youth in Gibraltar and Trinidad, where his father, the late Sir Henry Jackson, was Governor. He was educated in England at Downside School, and in the first world war served in France and Flanders as an artillery officer.

He had studied law on leaving school, and intended to make it his profession, but in 1921 he joined the then Anglo-Persian Oil Company, now The British Petroleum Company.

Until 1929 he worked in the Company's Production Department in London. In the following year he was appointed to head the office which the Company then established in New York, to deal with such matters as purchase and supply of oilfield and refinery equipment, patent rights, and maintaining contact with U.S. petroleum industry developments.

After five years in that post, he returned to London after accompanying the then Chairman (Sir John, later Lord, Cadman) in 1934 on a tour of the Company's installations in Australia and the Middle East.

From 1935 to 1939 Mr Jackson's main charge in London was the discovery and development of petroleum in the U.K., following the British Government's Petroleum (Production) Act, 1934.

Shortly after the outbreak of the second world war, Mr Jackson resumed charge of the Company's New York office. In 1941 the U.S. Petroleum Administrator for War appointed him one of the two British members of the Foreign Operations Committee. He had many difficult problems of wartime procurement to solve, Abadan's alkylation plant for the manufacture of aviation spirit for the Allies being an outstanding instance. Its plant and equipment had to be obtained and shipped to Iran in a race against time as fast as deliveries and U-boats, which sank several cargoes of it, permitted.

Between the end of the war and 1949, when he returned to London as a managing director of the company, having been appointed to the board in 1948, Mr Jackson's duties in connexion with its post-war development brought him into close contact with the petroleum industry throughout the U.S.A., Canada, and South America. In 1950 he spent several months in the Middle East revisiting B.P.'s interest in Iran, Kuwait, and Iraq; and in July of that year he became deputy-chairman to Sir William Fraser (later Lord Strathalmond).

In May 1951 Dr Musaddiq's Government nationalized the Iranian oil industry, and in June Mr Jackson headed a company mission to Teheran to try to negotiate a settlement of the Company's interests in Iran; only to meet with the same lack of success as attended the many subsequent attempts to negotiate with Dr Musaddiq until he fell from power in 1953.

After 1951 Mr Jackson and his colleagues bore the double load of the three-year complications of the Iranian dispute and settlement and of re-organizing Anglo-Iranian's interests outside Iran: re-settling displaced staff, re-forming market supply lines, increasing existing refinery capacity and building new refineries, and expanding crude oil production.

In April 1956 Mr Jackson succeeded Lord Strathalmond as Chairman, but at the end of January 1957 ill health compelled him to resign from that position.

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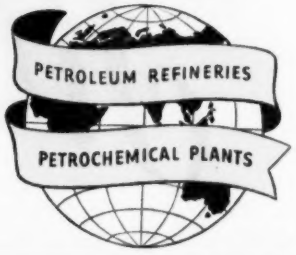

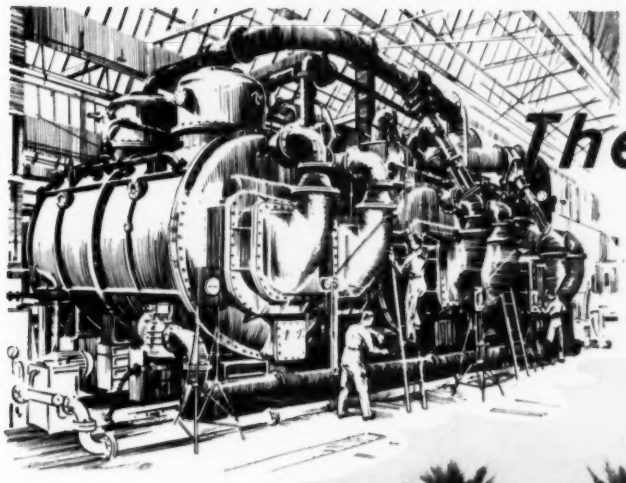

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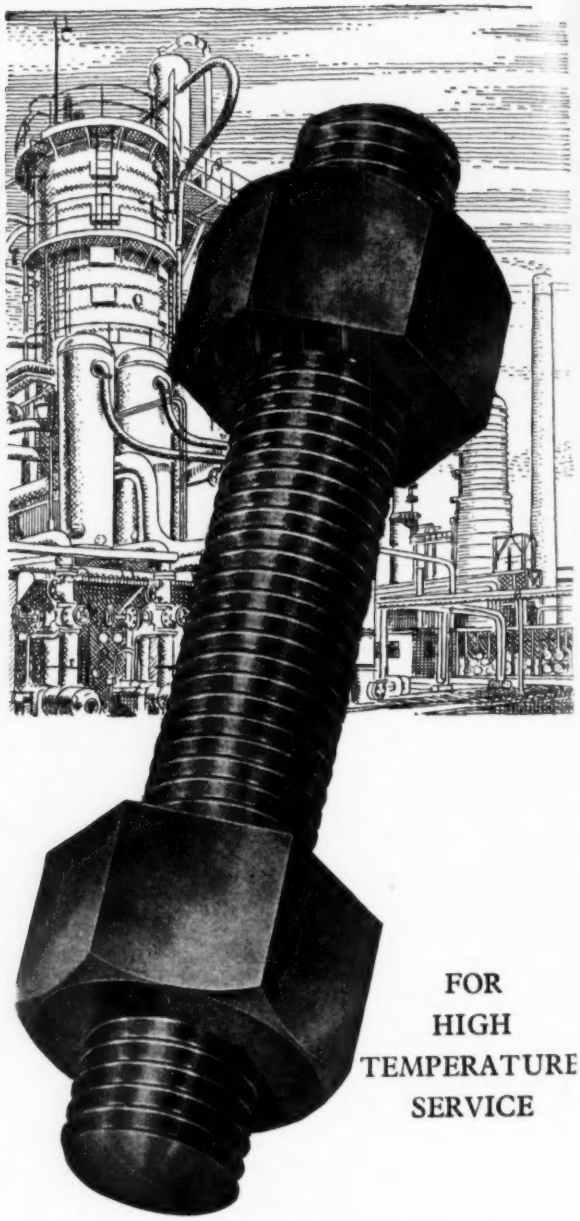

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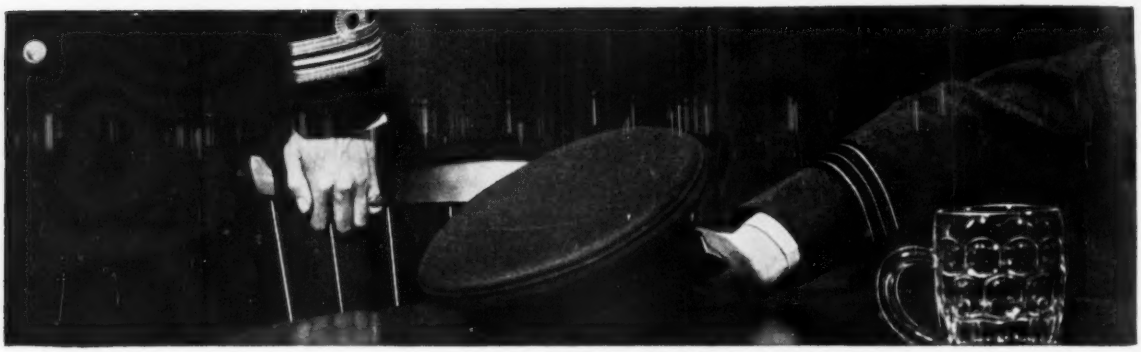
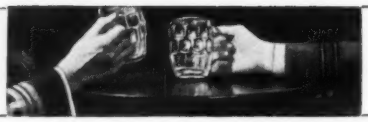
let's sit down...



Let's sit down and talk about cricket, the weather... anything so long as it isn't your confounded Simmonds Fram Separators.

Sorry old man... didn't mean to bore you.



That's quite all right. Delighted to know the R.A.F. is getting up to date. So you actually fly your planes on kerosene now instead of water!

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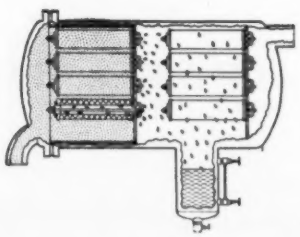

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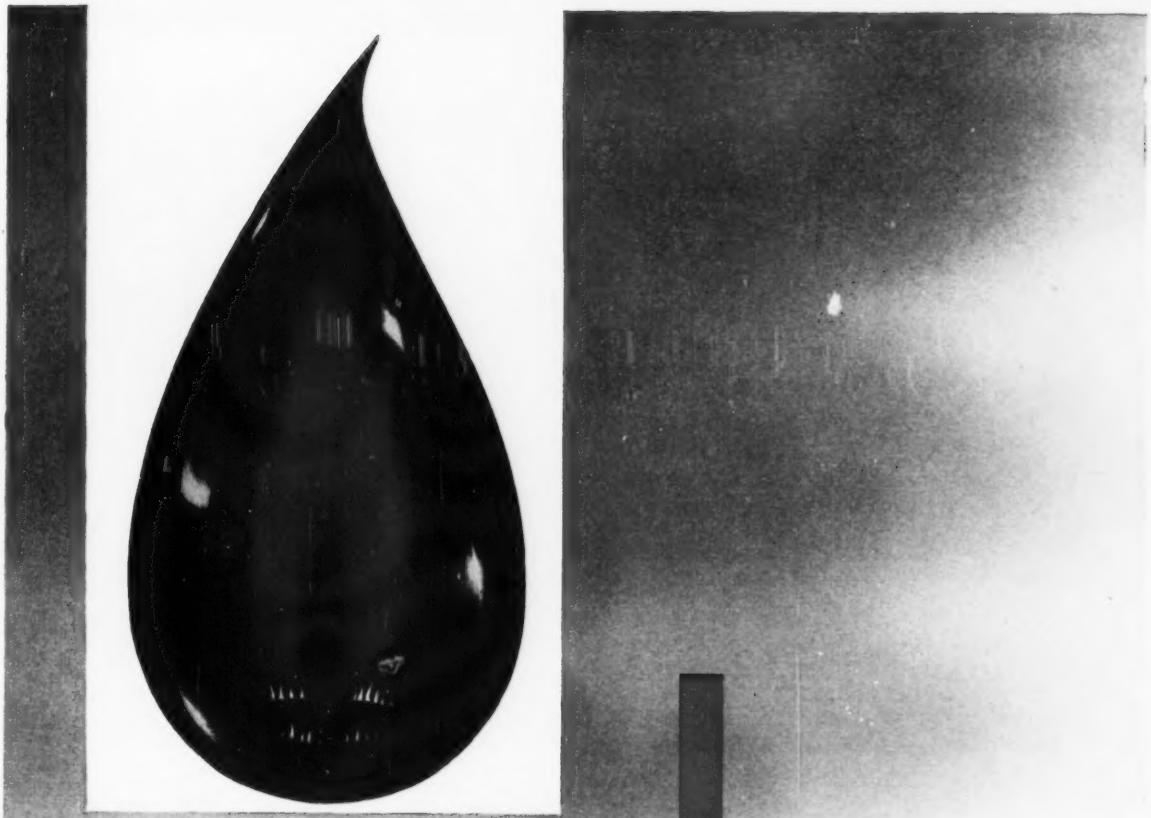

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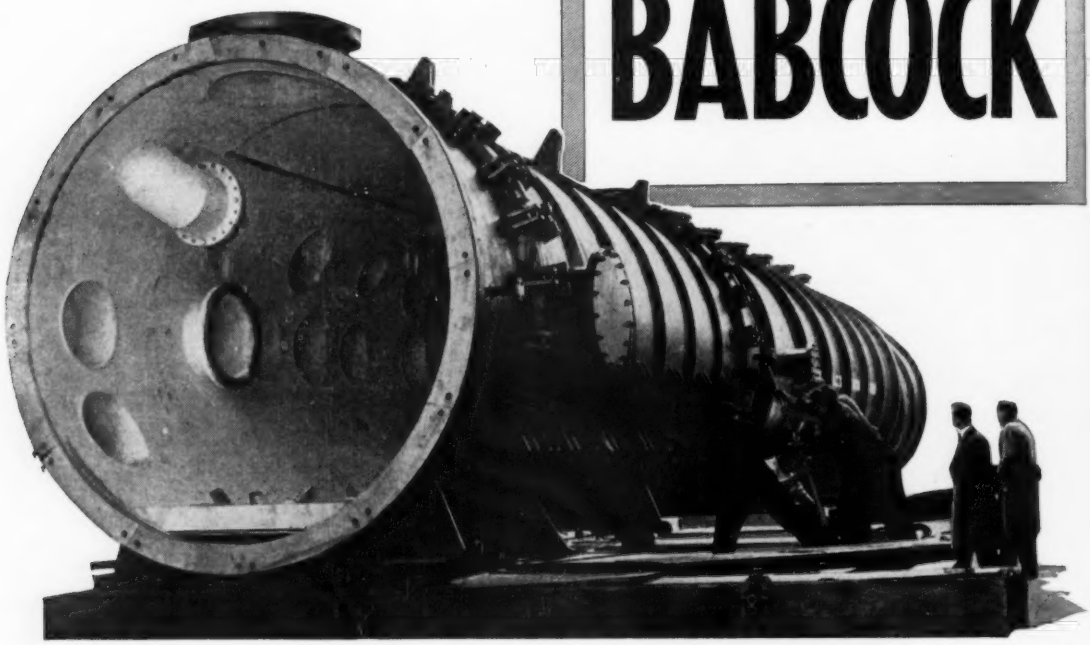


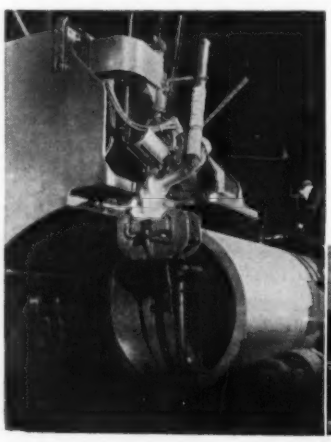
versatile FUSION WELDING

Bottom Right

A Babcock fusion-welded treating tower prior to despatch from the Company's Renfrew Works.

Below

Automatic fusion-welding of a thick-walled pressure vessel at Renfrew Works.



The 75 ft.-long by 10 ft.-diameter pressure vessel shown above during installation at the Patchway Works of Bristol Aero-Engines Limited, is part of a special test cell nearly 90 ft. long fabricated by Babcock & Wilcox Ltd. in molybdenum steel, by the *BABCOCK fusion-welding process.*

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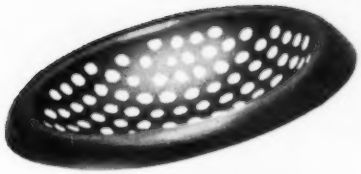

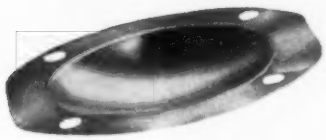

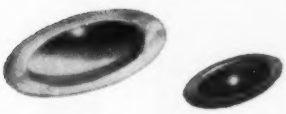

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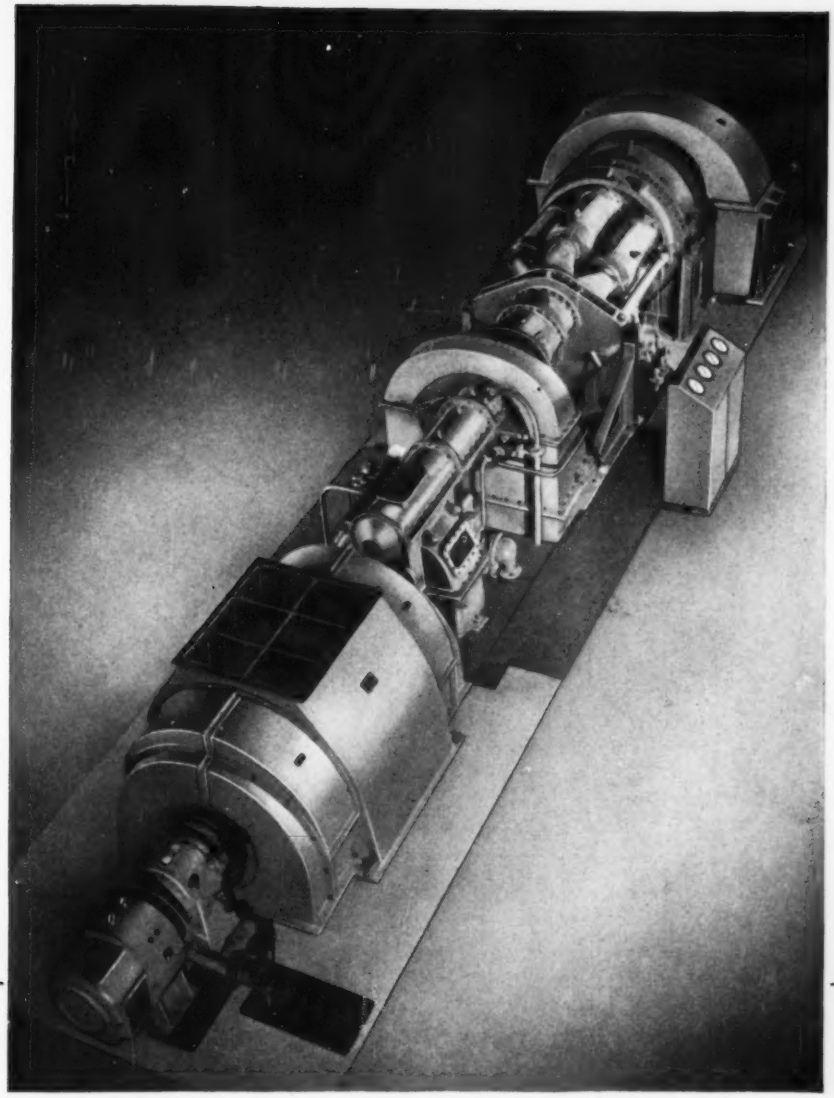

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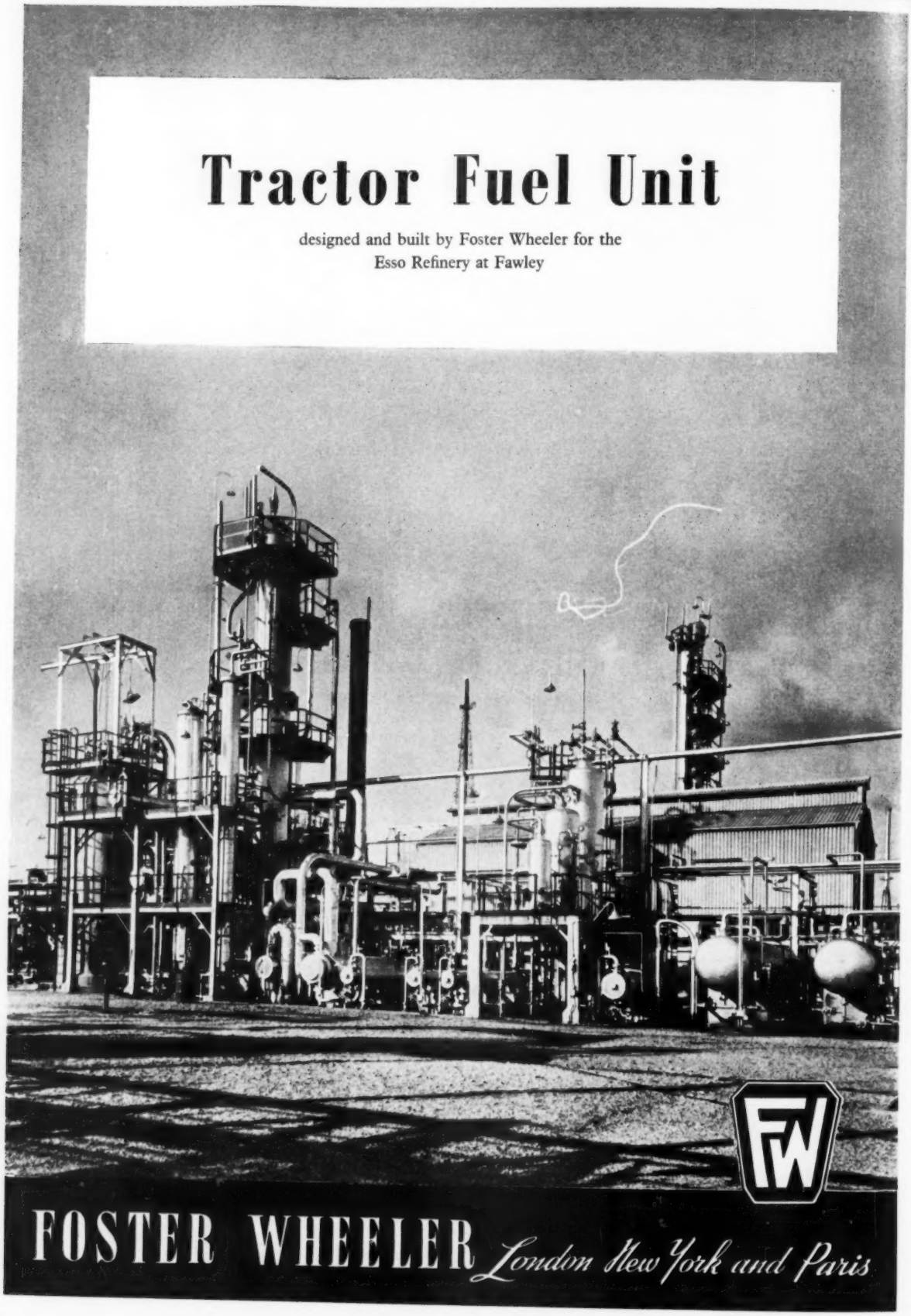
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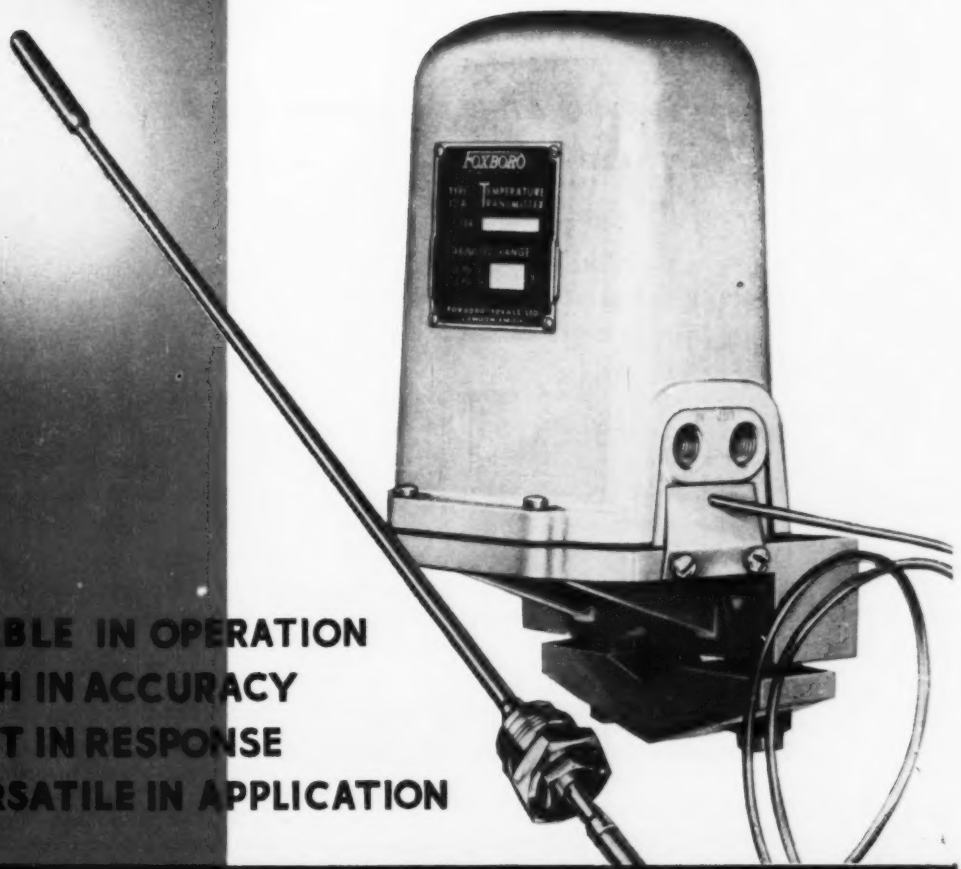

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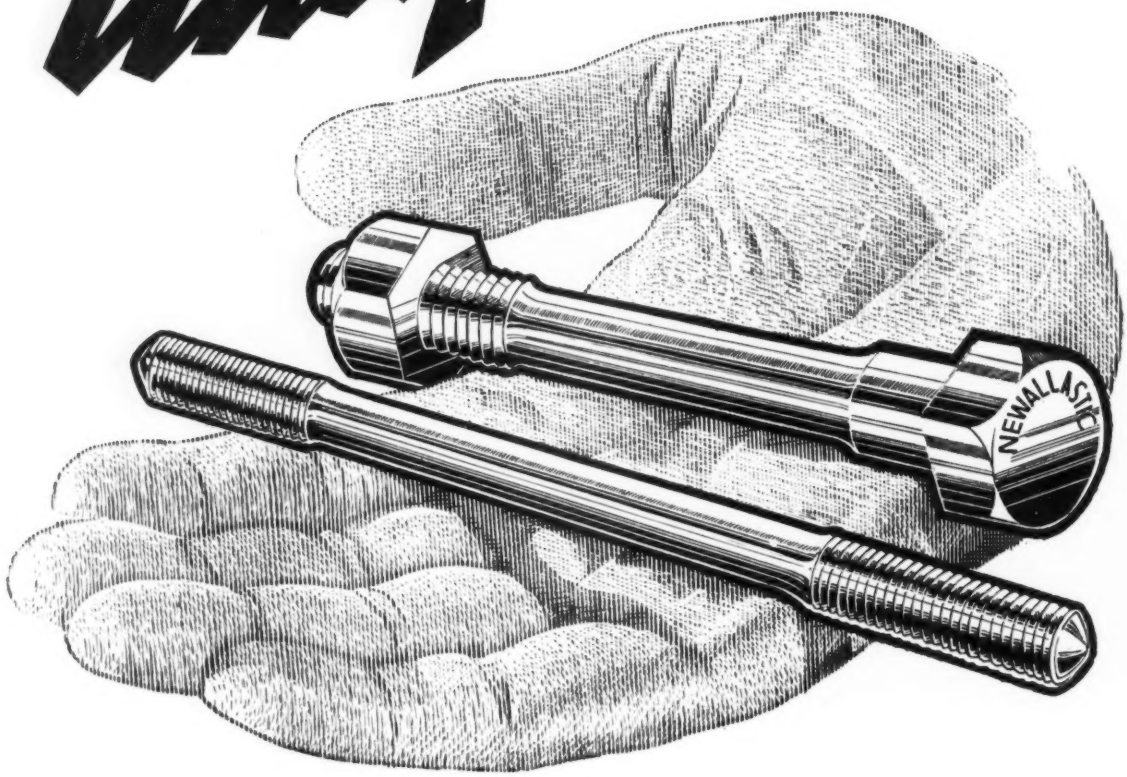

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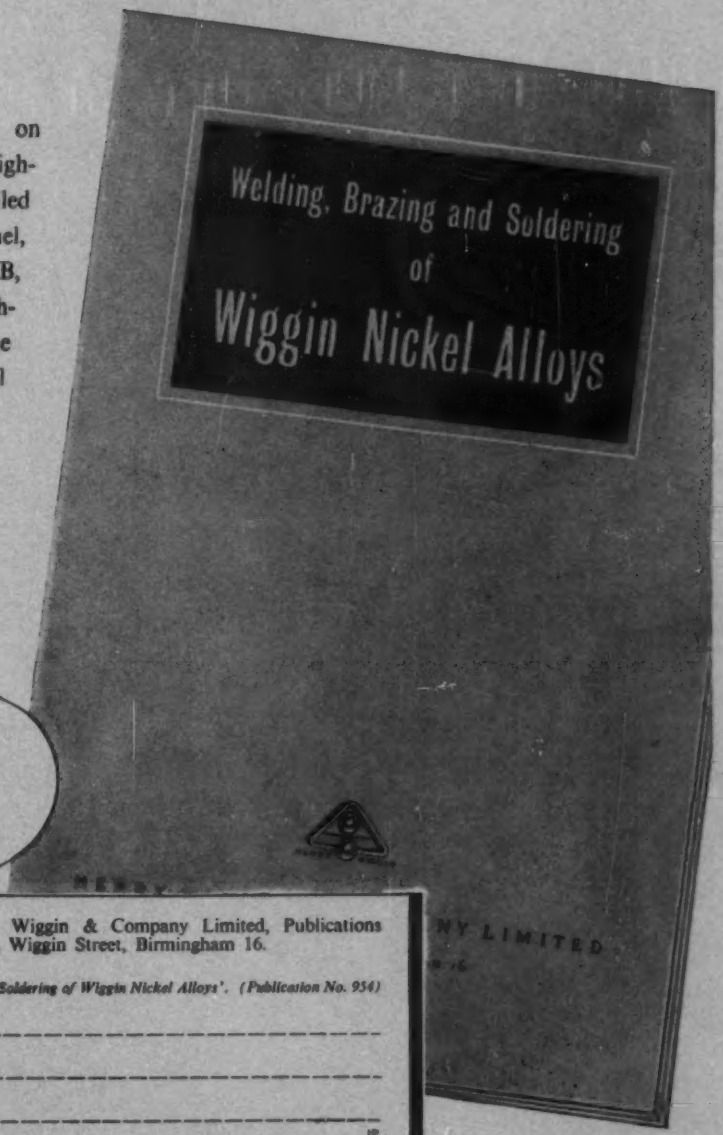

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